C. ASSESSMENT OF GOLDEN TILEFISH (*Lopholatilus chamaeleonticeps)* in the Middle Atlantic-Southern New England Region

A Report of the
Southern Demersal Working Group
National Marine Fisheries Service
Northeast Fisheries Science Center
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EXECUTIVE SUMMARY

Terms of Reference (TOR):

1. *Characterize the commercial catch including landings and discards. Characterize recreational landings.*
This TOR was completed. See Section 2.0.

2. *Estimate fishing mortality and total stock biomass for the current year and characterize the uncertainty of those estimates.*
This TOR was completed. See Section 3.0.

3. *Evaluate and either update or re-estimate biological reference points as appropriate.*
This TOR was completed. See Section 3.0.

4. *Where appropriate, estimate a constant TAC and/or TAL based on stock status for years following the terminal assessment year.*   This TOR is covered in TOR 5.

5. *If projections are possible,*

    a) provide seven year projections of stock status under various TAC
       strategies and

    b) evaluate current and projected stock status against existing rebuilding or
       recovery schedules, as appropriate.

This TOR was not carried out because of concerns related to the wide variance and substantial bias in the projection realizations. See Section 4.0.

6. Review, evaluate and report on the status of the research recommendations offered in the 1999 Science and Statistical committee reviewed assessment.
This TOR was completed. See Section 7.0.

The current status for this stock is based on the ASPIC surplus production model employed in the past 2 assessments. The model is calibrated with CPUE series, as there are no fishery-independent sources of information on trends in population abundance. While the Working Group expressed concern about the projection phase of this analysis, we agreed to accept the estimates of current fishing mortality and biomass and associated reference points.

Total commercial landings (live weight) increased from less than 125 metric tons (mt) during 1967-1972 to more than 3,900 mt in 1979 and 1980. Annual landings have ranged between 666 and 1,838 mt from 1988 to 1998. Landings from 1999 to 2002 were below 900 mt (ranging from 506 to 874 mt). An annual quota of 905 mt was implemented in November of 2001. During the late 1970s and early 1980s Barnegat, NJ was the principal tilefish port; more recently Montauk, NY has accounted for most of the landings.

Three different series of longline effort data were analyzed. The first series was developed by Turner (1986) who used a general linear modeling approach to standardize tilefish effort during 1973-1982 measured in kg per tub (0.9 km of groundline with a hook every 3.7 m) of longline fished obtained from logbooks of tilefish fishermen. Two additional CPUE series were calculated from the NEFSC weighout (1979-1993) and the VTR (1995-2004) systems. The number of vessels targeting tilefish has declined over the time series; during 1995-2002, five vessels accounted for more than 70 percent of the total tilefish landings. The length of a targeted tilefish trip had been generally increasing until the mid 1990s. Since then there appears to have been a trend towards shortening of the tilefish trips.

Six market categories exist in the database. From smallest to largest they are: small, kitten, medium, large and extra large as well as an unclassified category. The proportion of landings in the kittens and small market categories increased in 1995 and 1996. Evidence of two strong recruitment events can be seen tracking through these market categories. The proportion of large market category has declined since the early 1980s. Commercial length sampling has been inadequate over most of the time series. However some commercial length sampling occurred in the mid to late 1990s. More recently there has been a substantial increase in the commercial length sampling in 2003 and 2004.

A small recreational fishery occurred briefly in the mid 1970s (< 100 mt annually) but subsequent recreational catches have been quite low for the last 25 years (i.e., less than 1 mt caught annually). Directed tilefish trips are rare. Since 2000, only 2 trips in the MRFSS data had tilefish reported as the primary target species.

Thirteen different configurations of the ASPIC model were examined. The accepted formulation began the analysis in 1973, separated the Turner, weighout and VTR CPUE into three series and fixed the $B1/B_{msy}$ ratio at 1 as the final run (run 13). The surplus production model indicates that the tilefish stock biomass in 2005 has improved since the last assessment in 1998. Total biomass in 2005 is estimated to be 72% of B_{msy} and fishing mortality in 2004 is estimated to be 87% of F_{msy}. Biological reference points did not change greatly from the 1998 assessment. B_{msy} is estimated to be 9,384 mt and F_{msy} is estimated to be 0.21.

Results from several alternative models were also examined. Results from An Index Method (AIM) model also suggest that relative F is below the point that corresponds with a replacement ratio of 1 (stock replacement). MSY and Yield per recruit based biological reference points did not change greatly from the 1998 assessment. The Lagged Recruitment Survival Growth (LRSG) model produced results similar to the ASPIC surplus production model calibrated with the single linked CPUE series. However commercial length data indicate that increases in total biomass are predominantly due to a strong 1999 year class. Most of the commercial catch over the 2002-2004 period was derived from this year class.

Several ASPIC projections employing a constant TAC strategy, including the current TAC of 905 mt were examined Each of these analyses exhibited wide variance and substantial bias and, in many cases, produced estimates of biomass and F at maximum or minimum model boundary conditions. The projections are too uncertain to form the basis for evaluating likely biomass recovery schedules relative to B_{msy} under various TAC strategies. The Working Group does note, however, that stock biomass in 2005 (72% of B_{msy}) is above that projected for 2005 in the 1998 assessment (59% of B_{msy}). Thus, the existing TAC of 905 mt appears to have sufficiently constrained F to allow stock biomass to increase towards B_{msy}.

There are two major sources of uncertainty affecting our perception of current stock status. The biomass-based models (ASPIC, AIM and LRSG) use the CPUE series as an index of population size. The Working Group considered these models and expressed concerns over whether the CPUE in this fishery may be as much a reflection of changes in fishing practices and changes in spatial distribution of the fish rather than fluctuations in population size. The catch-length model attempts to reconcile recent fishing mortality rates with a less than expected representation of larger fish in the catch. Because there are no fishery-independent data on trends in population biomass and size structure, the model must assume that the length composition of the catch will represent the extent of large fish in the population assuming a flat topped partial recruitment pattern. Working Group comments are included as Appendix C1.

1.0 INTRODUCTION

Golden tilefish, *Lopholatilus chamaeleonticeps*, inhabit the outer continental shelf from Nova Scotia to South America, and are relatively abundant in the Southern New England to Mid-Atlantic region at depths of 80 to 440 m. Tilefish have a narrow temperature preference of 9 to 14 C. Their temperature preference limits their range to a narrow band along the upper slope of the continental shelf where temperatures vary by only a few degrees over the year. They are generally found in and around submarine canyons where they occupy burrows in the sedimentary substrate. Tilefish are relatively slow growing and long-lived, with a maximum observed age of 46 years and a maximum length of 110 cm for females and 39 years and 112 cm for males (Turner 1986). At lengths exceeding 70 cm, the predorsal adipose flap, characteristic of this species, is larger in males and can be used to distinguish the sexes. Tilefish of both sexes are mature at ages between 5 and 7 years (Grimes et. al. 1988).

Golden Tilefish was first assessed at SARC 16 in 1992 (NEFSC 1993). The Stock Assessment Review Committee (SARC) accepted a non-equilibrium surplus production model (ASPIC). The ASPIC model estimated biomass-based fishing mortality (F) in 1992 to be 3-times higher than F_{msy}, and the 1992 total stock biomass to be about 40% of B_{msy}. The intrinsic rate of increase (r) was estimated at 0.22.

The Science and Statistical (S&S) Committee reviewed an updated tilefish assessment in 1999. Total biomass in 1998 was estimated to be 2,936 mt, which was 35% of B_{msy} = 8,448 mt. Fishing mortality was estimated to be 0.45 in 1998, which was about 2-times higher than F_{msy} = 0.22. The intrinsic rate of increase (r) was estimated to be 0.45. These results were used in the development of the Tilefish Fishery Management Plan (Mid-Atlantic Fishery Management Council 2000). The Mid-Atlantic Fishery Management Council implemented the Tilefish Fishery Management Plan (FMP) in November of 2001. Rebuilding of the tilefish stock to B_{msy} was based on a ten-year constant harvest quota of 905 mt.

TOR 1: *Characterize the commercial catch including landings and discards.*
Characterize recreational landings.

2.0 DATA SOURCES

Commercial catch data

Total commercial landings (live weight) increased from less than 125 mt during 1967-1972 to more than 3,900 mt in 1979 and 1980 (Table C1, Figure C1). Landings stabilized at about 2,000 mt during 1982-1986. An increase in landings occurred in 1987 to 3,200 mt but subsequently declined to 450 mt in 1989. Annual landings have ranged between 454 and 1,838 mt from 1988 to 1998. Landings from 1999 to 2002 were below 900 mt (ranging from 506 to 874 mt). An annual quota of 905 mt was implemented in November of 2001. Landings in 2003 and 2004 were over the quota at 1,130 and 1,182 mt respectively. Over 75% of the landings came from Statistical Areas 537 and 616 since

1991 (Table C2). Since the 1980s, over 85% of the commercial landings of tilefish in the MA-SNE region have been taken in the longline fishery (Table C3, Figure C2). During the late 1970s and early 1980s Barnegat, NJ was the principal tilefish port; more recently Montauk, NY has accounted for most of the landings. The shift in landings can be seen in the proportion of the landings by state in Table C4 and Figure C3. In the late 1970s and earlier 1980s a greater proportion of the landings were taken in quarters 1 and 2 (Table C5, Figure C4). Recent landings have been relatively constant over the year.

Commercial discard data

Very little discarding (< 1%) of tilefish was reported in the vessel trip report (VTR) from longline vessels that target tilefish and there is little reported discarding of tilefish in the trawl fishery in the VTR data (Table C6). The highest trawl reported total discard of tilefish was 13 mt in 2003. Observer trawl data did not produce a reliable discard estimates for tilefish. Discard to kept ratios for trawl trips that either kept or discarded tilefish in the observer data varied from 0 in 1993 to 1.4 in 2001 (Table C7). Since 1989, twelve of the sixteen years had less than 15 trips sampled that caught tilefish.

Commercial CPUE data

Analyses of catch (landings) and effort data were confined to the longline fishery since directed tilefish effort occurs in this fishery (e.g. the remainder of tilefish landings are taken as bycatch in the trawl fishery). Most longline trips that catch tilefish fall into two categories: (a) trips in which tilefish comprise greater than 90% of the trip catch by weight and (b) trips in which tilefish accounted for less than 10% of the catch. Effort was considered directed for tilefish when at least 75% of the catch from a trip consisted of tilefish (NEFSC 1993).

Three different series of longline effort data were analyzed. The first series was developed by Turner (1986) who used a general linear modeling approach to standardize tilefish effort during 1973-1982 measured in kg per tub (0.9 km of groundline with a hook every 3.7 m) of longline obtained from logbooks of tilefish fishermen. Two additional CPUE series were calculated from the NEFSC weighout (1979-1993) and the VTR (1995-2004) systems as well as a combined 1979-2004 series. Effort from the weighout data was derived by port agents' interviews with vessel captains whereas effort from the VTR systems comes directly from mandatory logbook data. In this assessment and in the 1998 tilefish assessment we used Days absent as the best available effort metric. In the 1998 assessment an effort metric based on Days fished (average hours fished per set / 24 * number of sets in trip) was not used because effort data were missing in many of the logbooks and the effort data were collected on a trip basis as opposed to a haul by haul basis. For this assessment effort was calculated as:

$$Effort = Days\ absent - Number\ of\ trips,$$

where, Days absent = (time & date landed - time & date sailed).
For some trips, the reported days absent were calculated to be a single day. This was considered unlikely, as a directed tilefish trip requires time for a vessel to steam to near the edge of the continental shelf, time for fishing, and return trip time (Grimes et al.

1980). Thus, to produce a realistic effort metric based on days absent, a one day steam time for each trip (or the number of trips) was subtracted from days absents and therefore only trips with days absent greater than one day were used.

The NEFSC Weighout and VTR CPUE series were standardized using a general linear model (GLM) incorporating year and individual vessel effects (Mayo et al. 1994). The CPUE was standardized to an individual longline vessel and the year 1984; the same year used in the last assessment. For the VTR series the year 2000 was used as the standard. Model coefficients were back-transformed to a linear scale after correcting for transformation bias (Granger and Newbold 1977). The full GLM output for the Weighout CPUE series is included as Appendix C2 and the full GLM output for the VTR CPUE series is included as Appendix C3.

The number of vessels targeting tilefish has declined over the time series (Table C8, Figure C5); during 1995-2002, five vessels accounted for more than 70 percent of the total tilefish landings (Table C9, Figure C6). In 2003 and 2004 there appears to be an increase in the number of vessels targeting tilefish. The length of a targeted tilefish trip had been generally increasing until the mid 1990s. Since then there appears to have been a trend towards decreasing trip length (Figure C5). In the weighout data the small number of interview is a source of concern; very little interview data exists at the beginning of the time series (Table C8, Figure C7). The 5 dominant tilefish vessels make up almost all of the VTR data with the exception of 2004 when there appears to be more vessels targeting tilefish (Figure C6). In some years there were higher total landings reported in the VTR data than the Dealer data for the 5 dominant tilefish vessels.

The number of targeted tilefish trips declined in the early 1980s while trip length increased (Figures C5 and C8). More recently the number of trips became relatively stable as trip length decreased. The interaction between the number of vessels, the length of a trip and the number of trips can be seen in the total days absent trend in Figure C8. Total days absent remained relatively stable in the early 1980s, but then declined at the end of the weighout series (1979-1994). In the beginning of the VTR series (1994-2004) days absent increased through 1998 but declined thereafter. Figure C8 also shows that a smaller fraction of the total landings were included in the calculation of CPUE compared to the VTR series.

Figure C9 illustrates difference between the nominal CPUE and vessel standardized (GLM) CPUE with the weighout and VTR data combined. A large increase in CPUE can be seen in both series in recent years. CPUE trends are similar for most vessels that targeted tilefish (Figure C10). The sensitivity of the GLM model to sporadic vessels entering the CPUE series was tested by limiting the CPUE data set to vessels that were represented for at least 2 years, 3 years, 4 years, 5 years, and 6 years (Figures C11 to C15). This trimming of the data had very little influence on the resulting standardized GLM CPUE trend (Figure C16).

Very little CPUE data exist for New York vessels in the 1979-1994 weighout series despite the shift in landing from New Jersey to New York before the start of the VTR series in 1994. The small amount of overlap between the weighout and VTR series is illustrated in Figures C17 and C18. Splitting the weighout and VTR CPUE series can be

justified by the differences in the way effort was measured and difference in the tilefish fleet between the series. In breaking up the series we omitted 1994 because there were very little CPUE data. The sparse 1994 data that existed came mostly from the weighout system in the first quarter of the year. Very similar trends exist in the four years of overlap between Turner (1986) CPUE and the weighout series (Figure C19).

A month vessel interaction was significant but explained only a small amount of the total sum of squares (6%*).* Adding a month - vessel interaction term to the GLM model had very little influence on the results (Figure C20). In addition, limiting the VTR series to the 5 dominant tilefish vessels also had little influence on GLM results. The GLM output for the weighout and VTR CPUE series standardized for individual vessel effects can be seen in Appendix C2 and C3.

Since 1979, the tilefish industry has changed from using cotton twine to steel cables for the backbone and from J hooks to circle hooks. In light of possible changes in catchability associated with these changes in fishing gear, the working group considered that it would be best to use the three available indices separately rather than combined into one or two series. The earliest series (Turner 1986) covered 1973-1982 when gear construction and configuration was thought to be relatively consistent. The Weightout series (1979-1993) overlapped the earlier series for four years and showed similar patterns (Figure C19) and is based primarily on catch rates from New Jersey vessels. The VTR (1995-2004) series is based primarily on information from New York vessels.

Commercial market category and size composition data

Six market categories exist in the database. From smallest to largest they are: small, kitten, medium, large and extra large as well as an unclassified category. In 1996 and 1997, the reporting of tilefish by market categories increased, with the proportion of unclassified catch declining to less than 20% (Table C10, Figure C21). The proportion of landings in the small and kitten market categories increased in 1995 and 1996. Small and kitten market categories had similar length distributions and samples were combined. Evidence of several strong recruitment events can be seen tracking through the market category proportions (Figures C21 and C22). The proportion of the large market category has declined since the early 1980s (Figure C22). Landings data obtained directly from the New York tilefish industry shows a similar decline in the proportion of the large market category between 1980 and 1990 (Figure C23).

Since 2000 commercial length samples from New York were measured in total length. All other commercial tilefish were measured in fork length. In 2005 port agents measured both total and fork length from 345 fish to determine a total to fork length conversion (Figure C24). A 45 cm fish has about a 2 cm difference between total and fork length. All total length measurement were converted to fork length using the total length to fork length regression.

Extensive size sampling was conducted in 1976-1982 (Grimes *et al.* 1980, Turner 1986) however that data are not available by market category. Since then commercial length sampling has been inadequate in most years (Table C10). However some commercial length sampling occurred in the mid to late 1990s. More recently there has been a

substantial increase in the commercial length sampling in 2003 and 2004 (Table C10). Commercial length sampling in New York has also increased since the last assessment in 1998. The large and medium market category length frequencies appear to have been relatively stable for years when more than 100 fish were measured (Figures C25 and C26). However the small market category exhibits shifts in the size distribution in certain years as strong year classes move through the fishery (Figure C27). The tracking of a year class can be seen as the cohort grows over the year in 2002 and 2003 (Figure C28).

The loligo-scup small mesh trawl fishery catches smaller tilefish than longline gear. This can be seen in many of the length frequency distributions of smalls and kittens for the trawl gear (Figure C29). Therefore trawl length frequency distribution where not used to characterize the catch (Table C11). Longline tilefish fishermen often receive forecasts from the draggers of when a strong year class will be entering the fishery.

Commercial length frequencies were expanded for years where sufficient length data exist (1995-1999 and 2002-2004) (Table C10). The large length frequency samples from 1996 to 1998 were used to calculate the 1995 to 1999 expanded numbers at length while the large length samples from 2001 and 2003 were used to calculate the 2002 expanded numbers at length. Evidence of strong 1993 and 1999 year classes can be seen in the expanded numbers at length in the years when length data existed (1995-1999 and 2002-2004) (Figure C30). The matching of modes in the length frequency with ages was done using the Turner (1986) aging study. At the end of 2004 the 1999 year class can be seen growing into the medium market category (Figure C30). In recent years it appears that most of the catch is made up of this 1999 year class. An increase in the landings and CPUE can be seen when the 1993 and 1999 year classes recruit to the longline fishery.

Recently 1,409 commercial lengths were taken from 17 hauls on 3 tilefish longline observer trips from three different vessels (October 2004, November 2004, and January 2005) (Figure C31). The observer length frequency data show slightly larger fish than in the expanded commercial length data, which could be explained by growth of the cohort since the trips were done at the end of the year (Figure C32). A comparison between recent commercial expanded length data to commercial length data collected by Turner et al. (1983) from 1974-1982 shows a shift in the landings to smaller fish (Figure C33).

Recreational data

A small recreational fishery occurred briefly in the mid 1970s (< 100 mt annually, Turner 1986) but subsequent recreational catches have been quite low for the last 25 years (i.e., less than 1 mt caught annually) (Table C12). Party and charter boat vessel trip reports also show low numbers of tilefish being caught since 1994 (Table C13). Directed tilefish trips are rare. Since 2000, only 2 trips in the MRFSS data had tilefish reported as the primary target species.

NEFSC Trawl survey data

Only a few fish per survey are caught during NEFSC bottom trawl surveys. This survey time series is not useful as an index of abundance for tilefish.

TOR 2: *Estimate fishing mortality and total stock biomass for the current year and characterize the uncertainty of those estimates.*

TOR 3: *Evaluate and either update or re-estimate biological reference points as appropriate.*

3.0 MORTALITY AND STOCK SIZE ESTIMATES

Surplus production model

The ASPIC surplus production model (Prager 1994; 1995) was the primary model used to determine fishing mortality, stock biomass and biological reference points (F_{msy}, and B_{msy}). Results of sensitivity runs with 13 different configurations of the ASPIC model were examined (Table C14). A comparison of runs 1-2, 3-4, 5-6, and 7-8 provides information on the effect of splitting the weighout and VTR CPUE series. Runs 3-4, and 5-6 also extend the landings time series in the past before the existence of CPUE data. Runs 3-4 extended landings to the end of World War II (1945) when effort was thought to be low and runs 5-6 extended the landings to the beginning of the landings time series (1916). A comparison of runs 7-8 with runs 1-2 evaluates the effect of using a GLM to standardize CPUE. Runs 9 through 11 reduced the increase in CPUE at the end of the VTR series to determine the sensitivity of recent increases in CPUE to the model results (Figure C34). Run 12 examines the effect of using a single CPUE series by combining Turner and the weighout/VTR CPUE series. Turner and weighout-based CPUE indices were combined using a regression on the four years of overlap between the indices (1979-1982) (Figure C35). Run 13 fixed the B1/B_{msy} ratio at 1.

Splitting of the weighout and VTR CPUE series did not have a strong effect on the model results. Extending the landings time series used in the model back to 1916 or 1945 when CPUE data do not exist also did not appear to influence the results. The use of a CPUE series standardized for vessels effects (GLM) produced little change in the results. Sensitivity runs that lowered the CPUE at the end of the VTR CPUE series had more of an influence on model results. Reducing the increase in CPUE at the end of the time series generally lowers the estimate of the intrinsic rate of increase. The sensitivity run that combined all of the CPUE series into a single index (run 12) provided a high estimate of the intrinsic rate of increase (r = 0.63). Large fluctuations in the B1/B_{msy} ratio between the model runs did not have a large influence on model results. The Working Group accepted the formulation that began the analysis in 1973, separated the Turner, weighout and VTR CPUE into three series and fixed the B1/B_{msy} ratio at 1 as the final run (run 13). The solution obtained from the final run was bootstrapped (1000 iterations) to obtain estimates of precision and bias. The complete ASPIC model output with bootstrap results is included as Appendix C4.

The surplus production model indicates that the tilefish stock biomass in 2005 has improved since the last assessment in 1998. Total biomass in 2005 is estimated to be

72% of B_{msy}, and fishing mortality in 2004 is estimated to be 87% of F_{msy} (Figure C36). Biological reference points did not change greatly from the 1998 assessment. B_{msy} is estimated to be 9,384 mt and F_{msy} is estimated to be 0.21 (Figure C37). Bootstrap iterations show highly variable estimates of 2005 total biomass to B_{msy} ratios (80% confidence intervals from 0.5 to 1.2) and 2004 F to F_{msy} ratios (80% confidence intervals from 0.5 to 1.3) (Figure C38, Appendix C4).

Catch-Length Model Mortality Estimates

A length-based fishing mortality estimate in the 1998 assessment for the 1996-1997 period was 0.65 using the Hoenig (1987) method and 1.12 using the Beverton and Holt (1957) method (Nitschke et al. 1998). In the present assessment a catch-length forward projection model was developed in an attempt to produce more accurate fishing mortality estimates based on growth and size information in the catch. Testing of the model produced reasonable results on a simulated population of tilefish when recruitment does not have a strong trend over time and the average growth is known. However the model could not fit both the catch length frequency and total landings data in the tilefish assessment. The model produced an unrealistic increase in F at the end of the time series. Substantial changes to model inputs (natural mortality, partial recruitment, and/or growth rate) were needed to eliminate the fitting conflict. The catch-length model was not considered as the primary model for determining stock status at this time because of the fitting problems and the uncertainty about the partial recruitment, natural mortality and growth. The expanded length frequency data for 2002-2004 indicates that most of the commercial landings were taken from a single year class (1999) comprising of relatively young fish (age 5 in 2004).

The longline tilefish fleet targets strong year classes by fishing areas where the catch rates are high. Spatial segregation of the stock by size and changes in fishing practices to keep catch rates high can result in a dome shaped partial recruitment pattern. The shape and changes over time of a possible dome is unknown. Assuming that natural mortality and growth are relatively well known, a severe dome shaped partial recruitment pattern is needed to allow fishing mortality to match the F trend seen in the ASPIC model. Conversely, if a flat top partial recruitment pattern is more likely to occur in the fishery, recent catches should have comprised more larger fish than were observed to allow the catch-length model to estimate a declining fishing mortality rate at the end of the time series. Although uncertainty in the input data and the paucity of length data from the fishery precluded the use of the catch-length model at this time, the model still calls attention to the lack of large fish seen in the catch in recent years for a stock which is thought to have a relatively low fishing mortality rate in recent years.

An Index Method (AIM)

An Index Method (AIM, NOAA Fisheries Toolbox V1.4.1) was used as an additional indicator of stock status. The Index Method can only accommodate a single CPUE series so the combined index was employed. AIM uses a statistical fitting procedure to determine the relationship between indices and landings to calculate a relative F. A

replacement ratio is estimated by dividing the annual CPUE index by a moving average of the previous five years of that index. At a replacement ratio of 1 the stock is sustained at the same level as the previous five years. At a level above 1 the stock is increasing and at a level below 1 the stock is declining. A relative F is calculated by dividing the catch by the three-point moving average of the catch rates centered on the year in which that catch occurred. The relative F needed to maintain the population can be computed from the plot comparing the relative F with the replacement ratio (Figure C39).

For tilefish, the replacement ratio has been increasing since 2001 and has been above 1.0 since 2002, and the current estimate of relative F for 2004 is well below the point corresponding to the replacement ratio of 1.0 (Figure C40, Appendix C5). This model indicates that relative F has declined in recent years (Figure C40).

Lagged Recruitment Survival Growth (LRSG) Model

A lagged-recruitment survival growth (LRSG) model (Hilborn and Mangel 1997) was developed for tilefish. This simple model includes a time lag for recruitment (L) and a lumped survival-growth parameter for biomass (s). The model was fit using catch biomass and combined catch-per-unit effort (CPUE) series during 1973-2004. The recruitment time lag was 4 years. Recruited biomass in year T+1 (B_{T+1}, age-4+) was derived from previous biomass, recruiting biomass (R_T), and catch (C_T) via

$$B_{T+1} \; = \; s \cdot B_T + R_T - C_T$$

Recruitment biomass was modeled using a Beverton-Holt curve with a time lag of L=4 years

$$R_T \; = \; \frac{B_{T-L}}{a + b \cdot B_{T-L}}$$

In the likelihood for CPUE, model observation errors were assumed to be iid (independent and identically distributed) multiplicative lognormal distributions with constant variance. CPUE was assumed proportional to age-4+ biomass raised to an exponent (δ). In practice, there was insufficient information to estimate δ and it was set

$$CPUE_T \; = \; q \cdot \left(B_T \right)^{\delta}$$

to unity.
Prior distributions were assumed to be uninformative, with the exception of stock-recruitment steepness. Broad uniform prior distributions were used for the initial biomass (B_0), survival (s), catchability (q), exponent (δ), and error variance (σ^2) parameters. A uniform prior of [0.2, 1] was initially used for the stock-recruitment steepness parameter (z). This initial model configuration led to a highest posterior density point estimate of z=0.88 indicating a highly resilient stock. However, the Hessian matrix for this model solution had a high condition number indicating substantial collinearity among

parameters. As a result, an informative truncated Gaussian prior for steepness was developed using the meta-analysis of Myers et al. (1999). Steepness estimates from the nearest taxonomic grouping were used to set the mean steepness for the prior. In this case, the closest group was striped bass (*Morone saxatalis*) with a steepness of z=0.82. The coefficient of variation for the steepness prior was assumed to be 20%. Realized steepness values constrained to be in the interval [0.2, 1.0].

The combined CPUE series was used, because the current configuration of the model allows only one index of abundance. The LRSG model provided a reasonable fit to the CPUE series (Figure C41). Standardized residuals (Figure C42) were smaller than 1.5 and they exhibited a moderate alternating high-low pattern across blocks of several years. Relative biomass estimates (B/B_{msy}) indicated that the tilefish stock had been fished down in the 1970s-1980s (Figure C43) and has moderately increased since then. Recent biomass estimates appear to be at or above the B_{msy} estimate obtained from this model. Relative exploitation rate estimates (H/H_{msy}) indicated that the tilefish stock experienced periods of overfishing during the 1980s-1990s (Figure C44). Recent exploitation rates appear to be relatively low but increasing. Overall the LRSG modeling results are more similar to the results obtained from the ASPIC model calibrated with the single linked CPUE series.

Yield and Spawning Stock Biomass per Recruit

Biological reference points from the Thompson-Bell yield per recruit (YPR) model (Thompson and Bell 1934) were not updated from the last assessment since updated data for the YPR analysis does not exist. However a value of F_{max} was calculated from the Catch-length model. A length based YPR analysis (NOAA Fisheries Toolbox V1.2.1) was also performed for comparison to F_{max} estimates derived from the Catch-length model and the original 1998 YPR analysis. The proportions mature-at-age and length were derived from estimates of maturity in 1978 and 1982 provided by Grimes et al. (1988) (Figure C45). In the 1998 YPR analysis the partial recruitment and weight at age was taken from the yield per recruit analysis (Ricker model) in Turner (1986). Von Bertalanffy growth parameters, a length weight relationship and a partial recruitment vector based on the landings length frequencies are used in the catch-length model and length based YPR model. The 1998 yield per recruit analysis provided an estimate of $F_{max} = 0.143$, the length based YPR model provided an estimate of 0.138 (Figure C46, Appendix C6) and the catch-length model estimated an F_{max} of 0.142 (Figure C47). The predicted length and age distribution at F_{max} from the catch-length model is shown in Figure C48.

TOR 4: *Where appropriate, estimate a constant TAC and/or TAL based on stock status for years following the terminal assessment year.*

TOR 5: *If projections are possible,*
> *a) provide seven year projections of stock status under various TAC strategies and*

b) evaluate current and projected stock status against existing rebuilding or recovery schedules, as appropriate.

4.0 Biomass and Fishing Mortality Projections

The Working Group examined several ASPIC projections employing a constant TAC strategy, including the current TAC of 905 mt. Each of these analyses exhibited wide variance and substantial bias and, in many cases, produced estimates of biomass and F at maximum or minimum model boundary conditions. The Working Group, therefore, concluded that the projections are too uncertain to form the basis for evaluating likely biomass recovery schedules relative to Bmsy under various TAC strategies. We do note, however, that stock biomass in 2005 (72% of B_{msy}) is above that projected for 2005 in the 1998 assessment (59% of B_{msy}). Thus, the existing TAC of 905 mt appears to have sufficiently constrained F to allow stock biomass to increase towards B_{msy}.

5.0 CONCLUSIONS

The Working Group accepted the ASPIC model solution but the projection results were considered too uncertain to form the basis for evaluating likely biomass recovery schedules relative to B_{msy} under various TAC strategies. The surplus production model indicates that the tilefish stock biomass in 2005 has improved since the last assessment in 1998. Total biomass in 2005 was estimated to be 72% of B_{msy} and fishing mortality in 2004 was estimated to be 87% of F_{msy}. MSY and Yield per recruit based biological reference points did not change greatly from the 1998 assessment. Results from the AIM model suggest that relative F is below the point that corresponds with a replacement ratio of 1.0 (stock replacement) and the LRSG model produced results similar to the ASPIC surplus production model. The AIM and LRSG require a single index of abundance. The ASPIC model, which allows for the separation of the CPUE indices, was used as the base model for status determination given the changes in commercial gear over time. However commercial length data indicate that improvements in total biomass are predominantly due to a strong 1999 year class. Most of the commercial catch was derived from this year class over the 2002-2004 period.

The partial recruitment pattern is unknown for the tilefish longline fishery because targeting of year classes to increase catch rates and market conditions will influence the size of fish landed. The price on the large market category in this fishery is particularly sensitive to the quantity of large fish landed. However there is still concern that fishing mortality may be higher than estimated by the surplus production model due to the relative lack of larger/older fish seen in the catch. The inability to characterize the actual partial recruitment pattern, the possibility of unknown refuge effects due to conflicts with lobster and trawl gear and effects of targeting incoming year classes introduce considerable uncertainty in interpreting CPUE from this fishery as a measure of stock abundance. Thus, there is concern that CPUE at the end of the series may be increasing faster than stock biomass. CPUE and catch length frequency data in this fishery may be as much a reflection of changes in fishing practices and the spatial distribution of the fish rather than fluctuations in population size.

With regard to the yield per recruit-based reference points and the results from the catch-length model, there is an issue of how appropriate it is to assume a flat top partial recruitment pattern given anecdotal information that the tilefish fleet will target single year classes and will optimize profits by fishing an area where the catch rates are higher on fish in the small and medium market category as opposed to an area (greater depth) where more valuable larger fish can be caught at a lower catch rate.

6.0 SOURCES OF UNCERTAINTY

There are two major sources of uncertainty affecting our perception of current stock status. The biomass-based models (ASPIC, AIM and LRSG) use the CPUE series as an index of population size. The Working Group considered these models and expressed concerns over whether the CPUE in this fishery may be as much a reflection of changes in fishing practices and changes in spatial distribution of the fish rather than fluctuations in population size. The catch-length model attempts to reconcile recent fishing mortality rates with a less than expected representation of larger fish in the catch. Because there are no fishery-independent data on trends in population biomass and size structure, the model must assume that the length composition of the catch will represent the extent of large fish in the population assuming a flat topped partial recruitment pattern. Specific sources of uncertainty are:

1) The effort metric (days absent) in the Weighout and VTR CPUE is a crude measure of effort and could be improved by collecting information (number and size of hooks, length of main line, soak time, time of day, depth fished and area fished) on a haul by haul basis and not by a trip basis.

2) The production models and index method (AIM) do not consider size or age structure of the population.

3) Sparse commercial length frequency sampling in many years.

4) The possible existence of a dome shaped partial recruitment pattern in the longline fishery depending on hook size and/or fishery practice such as areas/depth fished.

5) Possible shifts in growth relative to the Turner (1986) study and maturity at age/size from the Grimes *et al.* (1988) early 1980s study with increases in fishing mortality in the 1990s.

6) Effects of fishing on spawning success for a species that possesses sexual dimorphic growth and size specific competition for baited hooks.

7) Effects of fish behavior and fishing practice on the CPUE index as an assumed measure of population size.

8) Uncertainty in projections based on wide variance and substantial bias estimates.

7.0 RESEARCH RECOMMENDATIONS

1) Conduct a hook selectivity study to determine partial recruitment changes with hook size. Determine catch rates by hook size. Update data on growth, maturity, size structure, and sex ratios at length.

2) Collect data on spatial distribution and population size structure. This can help answer the question of the existence of a possible dome shaped partial recruitment pattern where larger fish are less vulnerable to the fishery due to spatial segregation by size.

3) Continue to develop the forward projecting catch-length model as additional length data becomes available. Investigate the influence of adding a tuning index of abundance and model estimated partial recruitment (logistic) to the catch-length model.

4) Collect appropriate effort metrics (number and size of hooks, length of main line, soak time, time of day, area fished) on a haul basis to estimate commercial CPUE.

5) Initiate a study to examine the effects of density dependence on life history parameters between the 1978-82 period and present.

6) Increased observer coverage in the tilefish fishery to obtain additional length data.

7) Develop a bioeconomic model to calculate maximum economic yield per recruit.

TOR 6: Review, evaluate and report on the status of the research recommendations offered in the 1999 Science and Statistical committee reviewed assessment.

Research recommendations from 1999 Science and Statistical Committee review

1) Ensure that market category distributions accurately reflect the landings.

This is not really a research recommendation. The catch-length model assumes that landings from all market categories are accurately accounted for and that the length frequency distributions for a market category are stable over time. Sampling of the commercial lengths has improved over the last two years.

2) Ensure that length frequency sampling is proportional to landings by market category.

This is not really a research recommendation. Commercial length sampling has been sporadic over the time series. In particular length samples from the large market category have been lacking. However commercial length sampling improved in 2003 and 2004.

3) Increase and ensure adequate length sampling coverage of the fishery.

Commercial length sampling improved in 2003 and 2004.

4) Update age- and length- weight relationships.

This TOR has not been addressed. Question why length-weight relationships would change. Growth data for tilefish should be updated and will be collected in a planned 2005-2006 hook selectivity study.

5) Update the maturity-at-age, weight-at-age, and partial recruitment patterns.

This TOR has not been addressed. Maturity and partial recruitment data will also be collected in the 2005-2006 hook selectivity study.

6) Develop fork length to total length conversion factors for the estimation of total length to weight relationships.

This work is in progress. Port agents are collecting data.

7) Incorporate auxiliary data to estimate r independent of the ASPIC model.

This TOR has not been addressed. Question if this can be done or should be done.

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TILEFISH TABLES

Table C1. Landings of tilefish in live metric tons from 1915-2004. Landings in 1915-1972 are from Freeman and Turner (1977), 1973-1989 are from the general canvas data, 1990-1993 are from the weighout system, 1994-2003 are from the dealer reported data, and 2004 is from dealer electronic reporting. - indicates missing data.

year	mt	year	mt
1915	148	1960	1,064
1916	4,501	1961	388
1917	1,338	1962	291
1918	157	1963	121
1919	92	1964	596
1920	5	1965	614
1921	523	1966	438
1922	525	1967	50
1923	623	1968	32
1924	682	1969	33
1925	461	1970	61
1926	904	1971	66
1927	1,264	1972	122
1928	1,076	1973	394
1929	2,096	1974	586
1930	1,858	1975	710
1931	1,206	1976	1,010
1932	961	1977	2,082
1933	688	1978	3,257
1934	-	1979	3,968
1935	1,204	1980	3,889
1936	-	1981	3,499
1937	1,101	1982	1,990
1938	533	1983	1,876
1939	402	1984	2,009
1940	269	1985	1,961
1941	-	1986	1,950
1942	62	1987	3,210
1943	8	1988	1,361
1944	22	1989	454
1945	40	1990	874
1946	129	1991	1,189
1947	191	1992	1,653
1948	465	1993	1,838
1949	582	1994	786
1950	1,089	1995	666
1951	1,031	1996	1,121
1952	964	1997	1,810
1953	1,439	1998	1,342
1954	1,582	1999	525
1955	1,629	2000	506
1956	707	2001	874
1957	252	2002	851
1958	672	2003	1,130
1959	380	2004	1,182

Table C2. Percent landings by statistical area. Landings before 1990 are taken from the general canvas data. Percent landings after 1993 are estimated from vessel trip reports.

year	unknown	626	622	616	537	526	525	other
1962	100%	0%	0%	0%	0%	0%	0%	0%
1963	65%	0%	0%	0%	4%	28%	0%	3%
1964	83%	0%	0%	0%	4%	14%	0%	0%
1965	83%	0%	0%	0%	1%	16%	0%	0%
1966	97%	0%	0%	0%	0%	1%	1%	0%
1967	96%	0%	0%	0%	0%	4%	0%	0%
1968	96%	0%	0%	0%	1%	0%	0%	3%
1969	93%	0%	0%	0%	2%	4%	0%	1%
1970	87%	0%	0%	0%	8%	5%	0%	0%
1971	99%	0%	0%	0%	0%	0%	0%	0%
1972	92%	0%	0%	1%	1%	0%	0%	6%
1973	0%	0%	0%	62%	16%	0%	0%	21%
1974	0%	0%	0%	51%	27%	0%	0%	22%
1975	0%	0%	0%	48%	34%	8%	0%	10%
1976	0%	0%	0%	58%	28%	13%	0%	1%
1977	1%	0%	0%	44%	32%	22%	0%	1%
1978	0%	0%	0%	29%	40%	31%	0%	0%
1979	0%	0%	0%	18%	37%	45%	0%	0%
1980	0%	0%	0%	22%	34%	44%	0%	0%
1981	0%	0%	0%	28%	37%	35%	0%	0%
1982	0%	0%	0%	19%	52%	27%	0%	2%
1983	0%	1%	0%	22%	54%	23%	0%	0%
1984	0%	1%	3%	9%	53%	34%	0%	1%
1985	0%	0%	2%	25%	33%	38%	2%	1%
1986	0%	0%	1%	28%	44%	25%	3%	1%
1987	0%	0%	0%	12%	53%	32%	1%	2%
1988	0%	1%	2%	21%	41%	32%	0%	2%
1989	0%	0%	1%	63%	9%	26%	1%	1%
1990	0%	2%	0%	15%	14%	36%	0%	33%
1991	0%	0%	1%	64%	25%	1%	0%	10%
1992	0%	0%	1%	22%	70%	5%	1%	1%
1993	0%	0%	2%	14%	72%	7%	3%	2%
1994	3%	0%	0%	10%	71%	0%	7%	9%
1995	1%	0%	0%	7%	90%	0%	1%	1%
1996	21%	0%	0%	27%	49%	0%	0%	3%
1997	23%	0%	0%	16%	57%	0%	0%	3%
1998	17%	0%	0%	9%	66%	1%	1%	7%
1999	3%	0%	0%	34%	55%	0%	0%	7%
2000	0%	0%	0%	41%	50%	2%	1%	6%
2001	0%	0%	0%	66%	26%	2%	0%	5%
2002	0%	0%	0%	50%	44%	0%	1%	5%
2003	1%	0%	0%	49%	39%	1%	1%	10%
2004	0%	0%	0%	21%	63%	1%	2%	14%

Table C 3. Landings of tilefish (mt, live) by gear. Number of length measurements are in parentheses. Landing berfore 1990 are from the general canvas data. Percent by gear per year are also given.

	Gear							Percent by Gear		
Year	longline		trawl		other		Total	longline	trawl	other
1962			167		2		169	0%	99%	1%
1963			121				121	0%	100%	0%
1964			596				596	0%	100%	0%
1965			614				614	0%	100%	0%
1966			437				437	0%	100%	0%
1967			51				51	0%	100%	0%
1968			30				30	0%	100%	0%
1969			30				30	0%	100%	0%
1970			57		1		58	0%	99%	1%
1971			62		1		62	0%	99%	1%
1972	93		26		2		121	77%	21%	2%
1973	370		24		1		394	94%	6%	0%
1974	531		33		22		586	91%	6%	4%
1975	588		111		11		710	83%	16%	2%
1976	950		58		1		1,010	94%	6%	0%
1977	1,772		309		1		2,082	85%	15%	0%
1978	2,938		309		10		3,257	90%	9%	0%
1979	3,362		449		156		3,968	85%	11%	4%
1980	3,794		94	(37)	0		3,889	98%	2%	0%
1981	3,366	(25)	128		5		3,499	96%	4%	0%
1982	1,935		49	(87)	6		1,990	97%	2%	0%
1983	1,857	(158)	8		11		1,876	99%	0%	1%
1984	2,003	(116)	6		1		2,009	100%	0%	0%
1985	1,929	(410)	31		0		1,961	98%	2%	0%
1986	1,874	(177)	76		0		1,950	96%	4%	0%
1987	3,029	(292)	180	(291)	0		3,210	94%	6%	0%
1988	1,319	(98)	42				1,361	97%	3%	0%
1989	421		33		0		454	93%	7%	0%
1990	852		22		0		874	97%	2%	0%
1991	1,164		25		0		1,189	98%	2%	0%
1992	1,497	(36)	155		0		1,653	91%	9%	0%
1993	1,597		241	(100)	0		1,838	87%	13%	0%
1994	764		22		0		786	97%	3%	0%
1995	617	(432)	47		2		666	93%	7%	0%
1996	1,009	(548)	111	(107)	0		1,121	90%	10%	0%
1997	1,699	(1,763)	80	(216)	30		1,810	94%	4%	2%
1998	1,179	(710)	142	(290)	21		1,342	88%	11%	2%
1999	466	(360)	29		31	(11)	525	89%	6%	6%
2000	451	(143)	45		11		506	89%	9%	2%
2001	811	(217)	62	(103)	2		874	93%	7%	0%
2002	757	(637)	84	(482)	10		851	89%	10%	1%
2003	987	(3,303)	131	(274)	13		1,130	87%	12%	1%
2004	507	(1,532)	191	(411)	484	(8)	1,182	43%	16%	41%

Table C4. Landings of tilefish (mt, live) by state. Number of length measurements are in parentheses. Landings before 1990 are from general canvas data. Percent by state per year are also given.

									Percent by State					
Year	ME	MA	RI	NY	NJ	other	Total		ME	MA	RI	NY	NJ	other
1962	0	28	31	57	42	12	169		0%	16%	18%	34%	25%	7%
1963	0	42	46	13	14	6	121		0%	35%	38%	10%	12%	5%
1964	0	102	424	37	30	2	596		0%	17%	71%	6%	5%	0%
1965	0	106	478	20	9	2	614		0%	17%	78%	3%	1%	0%
1966	0	13	366	55	3	2	437		0%	3%	84%	13%	1%	0%
1967	0	2	27	8	8	5	51		0%	4%	54%	16%	17%	9%
1968	0	1	23	3	3	0	30		0%	4%	76%	9%	11%	0%
1969	0	2	13	4	10	0	30		0%	7%	44%	15%	35%	0%
1970	0	8	36	3	10	1	58		0%	13%	62%	5%	17%	2%
1971	0	0	21	25	15	1	62		0%	1%	34%	40%	24%	2%
1972	0	2	3	6	111	0	121		0%	1%	2%	5%	92%	0%
1973	0	51	17	3	323	0	394		0%	13%	4%	1%	82%	0%
1974	0	163	21	22	380	0	586		0%	28%	4%	4%	65%	0%
1975	0	174	101	2	434	0	710		0%	24%	14%	0%	61%	0%
1976	0	212	56	23	718	0	1,010		0%	21%	6%	2%	71%	0%
1977	0	84	354	314	1,331	0	2,082		0%	4%	17%	15%	64%	0%
1978	0	95	292	969	1,900	0	3,257		0%	3%	9%	30%	58%	0%
1979	0	22	432	1,365	2,148	0	3,968		0%	1%	11%	34%	54%	0%
1980	0	1	87 (37)	1,451	2,348	2	3,889 (37)		0%	0%	2%	37%	60%	0%
1981	0	6	126	1,284 (25)	2,083	1	3,499		0%	0%	4%	37%	60%	0%
1982	6	5	42 (87)	643	1,288	6	1,990 (87)		0%	0%	2%	32%	65%	0%
1983	0	12	7	844 (158)	1,001	12	1,876		0%	1%	0%	45%	53%	1%
1984	0	1	5	1,094	898 (116)	11	2,009 (116)		0%	0%	0%	54%	45%	1%
1985	2	10	207 (247)	958	777 (163)	6	1,961 (410)		0%	0%	11%	49%	40%	0%
1986	3	1	183 (70)	1,076 (107)	687	1	1,950 (177)		0%	0%	9%	55%	35%	0%
1987	0	7	269 (380)	1,996	924 (203)	13	3,210 (583)		0%	0%	8%	62%	29%	0%
1988	0	33	100 (98)	868	353	6	1,361 (98)		0%	2%	7%	64%	26%	0%
1989	0	1	28	249	174	1	454		0%	0%	6%	55%	38%	0%
1990	7	7	19	606	232	3	874		1%	1%	2%	69%	27%	0%
1991	4	1	19	720	444	1	1,189		0%	0%	2%	61%	37%	0%
1992	8	3	146	963 (36)	530	3	1,653		0%	0%	9%	58%	32%	0%
1993	59	14	276 (100)	1,003	485	1	1,838 (100)		3%	1%	15%	55%	26%	0%
1994	25	3	51	580	127	0	786		3%	0%	6%	74%	16%	0%
1995	8	1	29	551 (432)	76	1	666 (432)		1%	0%	4%	83%	11%	0%
1996	6 (108)	0	88 (219)	914	106 (328)	6	1,121 (655)		1%	0%	8%	82%	9%	1%
1997	13 (244)	0	65 (422)	1,494 (159)	196 (1,154)	41	1,810 (1,979)		1%	0%	4%	83%	11%	2%
1998	15	4	251 (320)	890 (74)	155 (606)	27	1,342 (1,000)		1%	0%	19%	66%	12%	2%
1999	3	2	86 (212)	362	43 (159)	30	525 (371)		1%	0%	16%	69%	8%	6%
2000	7	0	62	415 (143)	16	5	506 (143)		1%	0%	12%	82%	3%	1%
2001	0	0	33 (103)	832 (217)	4	4	874 (320)		0%	0%	4%	95%	0%	0%
2002	4	9	72 (482)	722 (637)	32	11	851 (1,119)		0%	1%	8%	85%	4%	1%
2003	2 (343)	12	105 (167)	796 (1,862)	208 (1,205)	7	1,130 (3,577)		0%	1%	9%	70%	18%	1%
2004	0 (31)	117 (19)	136 (345)	601 (351)	318 (1,205)	10	1,182 (1,951)		0%	10%	12%	51%	27%	1%

Table C5. Landings of tilefish (mt, live) by quarter. Number of length measurements are in parentheses. General canvas data are not included. Percent by quarter per year are also given.

Year	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total	1	2	3	4
1977	1,017		961		93		12		2,082	49%	46%	4%	1%
1978	905		1,128		432		793		3,257	28%	35%	13%	24%
1979	1,351		1,055		538		1,024		3,968	34%	27%	14%	26%
1980	1,524		1,263	(37)	505		596		3,889	39%	32%	13%	15%
1981	1,352		1,091		474		581	(25)	3,499	39%	31%	14%	17%
1982	1,028	(87)	433		239		289		1,990	52%	22%	12%	15%
1983	577	(119)	726		289	(39)	284		1,876	31%	39%	15%	15%
1984	1,032		491	(116)	293		193		2,009	51%	24%	15%	10%
1985	551	(340)	632	(70)	496		281		1,961	28%	32%	25%	14%
1986	542	(107)	597	(70)	437		374		1,950	28%	31%	22%	19%
1987	1,048	(481)	873		723	(102)	565		3,210	33%	27%	23%	18%
1988	737		292	(98)	160		172		1,361	54%	21%	12%	13%
1989	147		61		78		167		454	32%	13%	17%	37%
1990	258		243		184		189		874	29%	28%	21%	22%
1991	326		437		182		244		1,189	27%	37%	15%	21%
1992	424		434		401		394	(36)	1,653	26%	26%	24%	24%
1993	634	(100)	664		267		273		1,838	34%	36%	15%	15%
1994	301		275		73		138		786	38%	35%	9%	18%
1995	214	(432)	148		109		195		666	32%	22%	16%	29%
1996	366	(215)	215		231		308	(440)	1,121	33%	19%	21%	28%
1997	441	(808)	574	(906)	373	(80)	421	(185)	1,810	24%	32%	21%	23%
1998	539	(324)	362	(517)	229	(104)	212	(55)	1,342	40%	27%	17%	16%
1999	163	(150)	146	(10)	120	(102)	96	(109)	525	31%	28%	23%	18%
2000	143		141	(143)	77		144		506	28%	28%	15%	28%
2001	191		236		223		224	(320)	874	22%	27%	25%	26%
2002	287	(619)	195	(100)	181	(217)	188	(183)	851	34%	23%	21%	22%
2003	305	(480)	299	(407)	247	(1,641)	280	(1,049)	1,130	27%	26%	22%	25%
2004	504	(1,711)	272	(240)	182		223		1,182	43%	23%	15%	19%

Table C6. Total VTR trawl kept and discarded tilefish in live kg. Ratios of discarded to kept are also shown.

year	kept	discard	d/k ratio
1994	3,090	113	0.037
1995	14,637	98	0.007
1996	90,405	656	0.007
1997	75,321	260	0.003
1998	121,042	206	0.002
1999	31,501	74	0.002
2000	20,785	0	0.000
2001	51,055	538	0.011
2002	69,722	2,053	0.029
2003	135,058	13,024	0.096
2004	222,540	273	0.001

Table C7. Observer trawl trips which either kept and/or discarded tilefish in kgs.
Discard to kept ratio, the number of trips and observed hauls are also shown.

year	discard kgs	kept kgs	d/k ratio	No. trips	No. hauls
1989	114	131	0.88	8	43
1990	9	85	0.11	4	11
1991	252	446	0.57	19	69
1992	182	855	0.21	22	84
1993	21	4,619	0.00	13	77
1994	14	119	0.11	7	23
1995	20	23	0.90	6	13
1996	56	1,515	0.04	11	53
1997	195	1,080	0.18	13	71
1998	45	518	0.09	11	92
1999	31	152	0.20	14	47
2000	116	112	1.04	8	25
2001	653	455	1.43	10	54
2002	5	58	0.08	3	6
2003	271	1,206	0.22	15	65
2004	250	1,592	0.16	30	160

Table C8. Total commercial and vessel trip report (VTR) landings in live mt and the commercial catch-per-unit effort (CPUE) data used for tilefish. Dealer landings before 1990 are from the general canvas data. CPUE data from 1979 to the first half of 1994 are from the NEFSC weighout database, while data in the second half of 1994 to 2004 are from the VTR system (below the dotted line). Effort data are limited to longline trips which targeted tilefish (= or >75% of the landings were tilefish) and where data existed for the days absent. Nominal CPUE series are calculated using landed weight per days absent minus one day steam time per trip. Da represents days absent.

| | Weighout & Dealer landings | vtr landings | Commerical CPUE data subset | | | | | | | | |
year			interview landings	No. interviews	% interview trips	No. vessels	subset landings	days absent	No. trips	da per trip	nominal cpue
1979	3,968		0.0	0	0.0%	20	1,807	1,187	330	3.6	1.93
1980	3,889		0.8	1	0.3%	18	2,153	1,390	396	3.5	1.99
1981	3,499		35.0	4	1.2%	21	1,971	1,262	333	3.8	1.95
1982	1,990		90.7	13	5.7%	18	1,267	1,282	229	5.6	1.10
1983	1,876		85.8	16	8.9%	21	1,013	1,451	179	8.1	0.73
1984	2,009		140.1	25	18.2%	20	878	1,252	138	9.1	0.72
1985	1,961		297.1	64	30.6%	25	933	1,671	209	8.0	0.59
1986	1,950		120.7	31	16.5%	23	767	1,186	188	6.3	0.71
1987	3,210		198.5	38	18.5%	30	1,014	1,343	206	6.5	0.82
1988	1,361		148.2	30	19.4%	23	422	846	154	5.5	0.56
1989	454		92.8	11	15.7%	11	165	399	70	5.7	0.46
1990	874		32.4	8	11.9%	11	241	556	68	8.2	0.45
1991	1,189		0.8	3	2.8%	7	444	961	107	9.0	0.48
1992	1,653		58.0	9	8.6%	13	587	969	105	9.2	0.62
1993	1,838		71.9	11	10.5%	10	571	959	105	9.1	0.61
1994	-		0	0	0.0%	7	127	385	42	9.2	0.34
1994	786	31				4	53	150	18	8.3	0.37
1995	666	549				5	470	964	100	9.6	0.50
1996	1,121	865				8	822	1,318	134	9.8	0.64
1997	1,810	1,439				6	1,427	1,332	133	10.0	1.09
1998	1,342	1,068				9	1,034	1,517	158	9.6	0.70
1999	525	527				10	516	1,185	133	8.9	0.45
2000	506	446				11	427	942	111	8.5	0.47
2001	874	705				8	691	1,046	116	9.0	0.68
2002	851	724				8	712	951	114	8.3	0.78
2003	1,130	790				7	788	691	101	6.8	1.22
2004	1,182	1,137				13	1,118	750	126	6.0	1.64

Table C9. Dealer and VTR tilefish total landings (live metric tons) compared to the total landings from the five dominant tilefish vessels. Percent of five dominant vessels to the total are also shown. Difference between the dealer and VTR data are calculated.

year	Dealer total (live mt)	Dealer top 5 vessels	Dealer % landing of top 5 vessels to total	VTR total (live mt)	VTR top 5 vessels	VTR % landing of top 5 vessels to total	Dealer total minus vtr total	Dealer top 5 minus vtr top 5
1994	786	485	62%	31	17	57%	755	467
1995	666	522	78%	549	538	98%	117	-16
1996	1,121	803	72%	865	799	92%	256	4
1997	1,810	1,292	71%	1,439	1,416	98%	371	-123
1998	1,342	948	71%	1,068	1,003	94%	274	-55
1999	525	399	76%	527	486	92%	-2	-87
2000	506	459	91%	446	428	96%	60	31
2001	874	817	93%	705	684	97%	169	133
2002	851	722	85%	724	687	95%	127	35
2003	1,130	726	64%	790	732	93%	340	-6
2004	1,182	584	49%	1,137	622	55%	45	-38

Table C10. Landing by market category. Number of length measurements are in parentheses. Percent by market category redistributes the unclassified category by the proportion of the other categories.

year	large		medium		small		unclassified		total	Percent by market cat		
										lg	md	sm
1980	0		0		0		3,889	(37)	3,889	-	-	-
1981	0		0		0		3,499	(25)	3,499	-	-	-
1982	18		9		6		1,957	(87)	1,990	55%	28%	18%
1983	13	(119)	7	(39)	2		1,854		1,876	59%	31%	10%
1984	49		47		18		1,895	(116)	2,009	43%	41%	16%
1985	218		206	(247)	111		1,426	(163)	1,961	41%	38%	21%
1986	359	(49)	223	(58)	168		1,200		1,950	48%	30%	22%
1987	300		663	(393)	134		2,113	(190)	3,210	27%	60%	12%
1988	120		161	(98)	36		1,043		1,361	38%	51%	11%
1989	47		27		33		347		454	44%	25%	31%
1990	46		103		37		688		874	25%	55%	20%
1991	85		154		59		892		1,189	29%	52%	20%
1992	86		87		328		1,151	(36)	1,653	17%	17%	65%
1993	70		206	(100)	368		1,193		1,838	11%	32%	57%
1994	61		89		19		617		786	36%	53%	12%
1995	93		88	(208)	99	(244)	386		666	33%	31%	35%
1996	158	(136)	149	(100)	593	(419)	221		1,121	18%	17%	66%
1997	112	(95)	260	(688)	1,130	(1,174)	307	(22)	1,810	7%	17%	75%
1998	110	(101)	699	(407)	474	(473)	58	(19)	1,342	9%	54%	37%
1999	115		201	(155)	181	(211)	29	(5)	525	23%	40%	36%
2000	124		153	(79)	210	(64)	18		506	25%	31%	43%
2001	131	(25)	160	(100)	564	(195)	19		874	15%	19%	66%
2002	132		311	(130)	369	(989)	40		851	16%	38%	45%
2003	141	(498)	162	(1,354)	793	(1,725)	35		1,130	13%	15%	72%
2004	136	(106)	520	(870)	395	(932)	130	(43)	1,182	13%	49%	38%

Table C11. Trawl landing by market category. Number of trawl length measurements are in parentheses. Percent by market category redistributes the unclassified category by the proportion of the other categories.

year	large	medium		small		unclassified		total	Percent by market cat		
									lg	md	sm
1994	2	7		9		4		22	12%	38%	51%
1995	9	10		22		7		47	22%	24%	54%
1996	5	4		72	(107)	31		111	6%	4%	90%
1997	4	4		40	(216)	31		80	9%	9%	82%
1998	7	48		41	(271)	45	(19)	142	7%	50%	42%
1999	6	7		10		7		29	27%	30%	43%
2000	11	10		16		6		45	30%	27%	43%
2001	13	7		27	(103)	14		62	28%	15%	57%
2002	3	20		47	(482)	15		84	4%	28%	68%
2003	2	12	(100)	85	(174)	32		131	2%	12%	86%
2004	4	55	(95)	82	(316)	49	(43)	191	3%	39%	58%

Table C12. Recreational Golden tilefish data from the Marine Recreational Fishery
Statistics Survey (MRFSS).

year	number fish measured	landed no. A and B1	Released B2	A and B1 kg
1982	0	984	0	98
1983	0	0	0	0
1984	0	0	0	0
1985	0	0	0	0
1986	0	0	0	0
1987	0	0	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	0	0	0	0
1992	0	0	0	0
1993	0	0	0	0
1994	0	608	0	0
1995	0	0	0	0
1996	0	10,167	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
2001	0	148	0	0
2002	0	20,068	1,338	0
2003	18	722	0	2,126
2004	3	90	0	206

Table C13. Number of tilefish reported in the Party/charter vessel trip reports.

year	ME	MD	NH	NJ	NY	NC	RI	VA	other	total
1994	275	0	636	0	0	0	0	0	0	911
1995	0	0	0	0	176	0	541	0	0	717
1996	0	0	0	0	81	0	0	0	0	81
1997	0	0	0	0	380	0	0	0	20	400
1998	0	0	0	0	121	52	102	0	20	295
1999	0	6	0	0	88	34	1	0	0	129
2000	0	0	0	39	108	139	0	0	0	286
2001	0	0	0	100	122	1,164	0	0	0	1,386
2002	0	0	0	383	425	0	0	0	0	808
2003	0	0	0	905	71	0	3	0	15	994
2004	0	0	0	225	0	0	0	27	12	264

Table C14. Comparison of 13 different ASPIC model runs for tilefish. Runs 1-2, 3-4, 5-6, and 7-8 split the weighout and VTR CPUE series. Runs 3-4, and 5-6 extend the landings time series in the past before the existence of CPUE data. Runs 7-8 uses the nominal weighout and VTR CPUE indices. Runs 9 through 11 reduced the increase in CPUE at the end of the VTR series to determine the sensitivity of recent increases in CPUE. Run 12 examines the effect of using a single CPUE series by combining Turner and the weighout/VTR CPUE series. Runs which combine indices use the weighout label to report the combined index r^2 and q. Run 13 fixed the B1/Bmsy ratio at 1 and was used as base run.

run	1	2	3	4	5	6	7	8	9	10	11	12	13
Description							nominal CPUE	nominal CPUE	vtr cpue no increase in last 3 years	vtr cpue no increase in last 2 years	vtr cpue decrease 2003 & 2004 CPUE	single CPUE Series	fix B1/Bmsy ratio to 1
Start year	1973	1973	1945	1945	1916	1916	1973	1973	1973	1973	1973	1973	1973
Number of CPUE series	2	3	2	3	2	3	2	3	3	3	3	1	3
r^2 (Turner)	0.39	0.55	0.48	0.53	0.50	0.53	0.55	0.57	0.60	0.57	0.58	-	0.18
r^2 (Weighout)	0.73	0.72	0.73	0.72	0.72	0.71	0.68	0.68	0.70	0.72	0.71	0.87	0.70
r^2 (VTR)	-	0.51	-	0.51	-	0.51	-	0.45	0.14	0.47	0.36	-	0.54
B1/Bmsy	4.61	2.12	1.08	5.39	10.51	8.46	2.25	2.19	2.44	2.19	2.28	2.51	1.00
MSY (live, mt)	1.87	1.83	1.94	1.84	1.92	1.84	1.87	1.75	1.56	1.76	1.69	2.14	1.99
r	0.47	0.42	0.47	0.42	0.47	0.42	0.45	0.38	0.30	0.39	0.35	0.63	0.42
K (mt)	15.87	17.39	16.30	17.42	16.51	17.44	16.82	18.40	20.54	18.17	19.12	13.67	18.77
B_{msy} (live, mt)	7.93	8.69	8.15	8.71	8.26	8.72	8.41	9.20	10.27	9.09	9.56	6.84	9.38
F_{msy} (live, mt)	0.24	0.21	0.24	0.21	0.23	0.21	0.22	0.19	0.15	0.19	0.18	0.31	0.21
q (Turner's)	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.008	0.007	0.008	0.007	-	0.010
q (Weighout)	0.235	0.217	0.241	0.218	0.235	0.184	0.162	0.139	0.160	0.200	0.183	0.31	0.225
q (VTR)	-	0.379	-	0.384	-	0.382	-	0.157	0.307	0.344	0.329	-	0.392
B(2005)/Bmsy	0.81	0.77	0.79	0.76	0.77	0.76	0.91	0.77	0.51	0.71	0.63	0.82	0.715
F(2004)/Fmsy	0.82	0.87	0.81	0.87	0.83	0.87	0.73	0.91	1.57	1.03	1.21	0.73	0.870

**TILEFISH FIGURES**

Total Landings
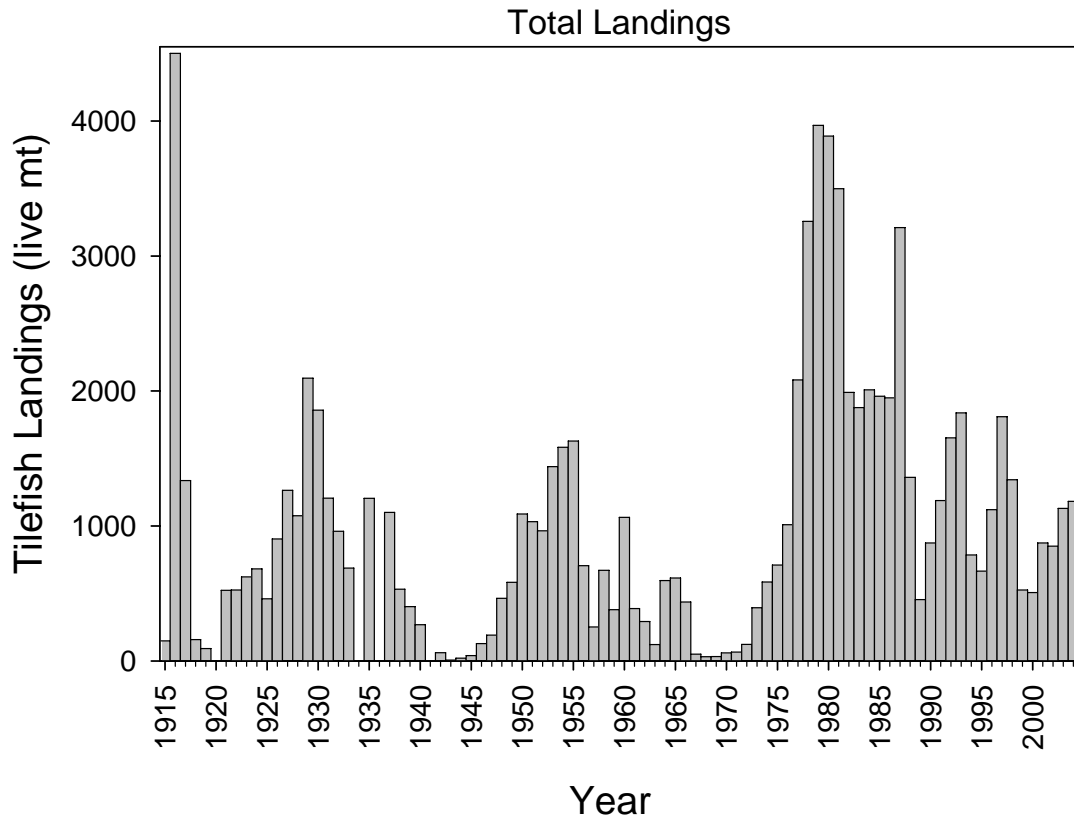
Figure C1. Landings of tilefish in metric tons from 1915-2004. Landings in 1915-1972 are from Freeman and Turner (1977),1973-1989 are from the general canvas data, 1990-1993 are from the weighout system, 1994-2003 are from the dealer reported data, and 2004 is from dealer electronic reportings.
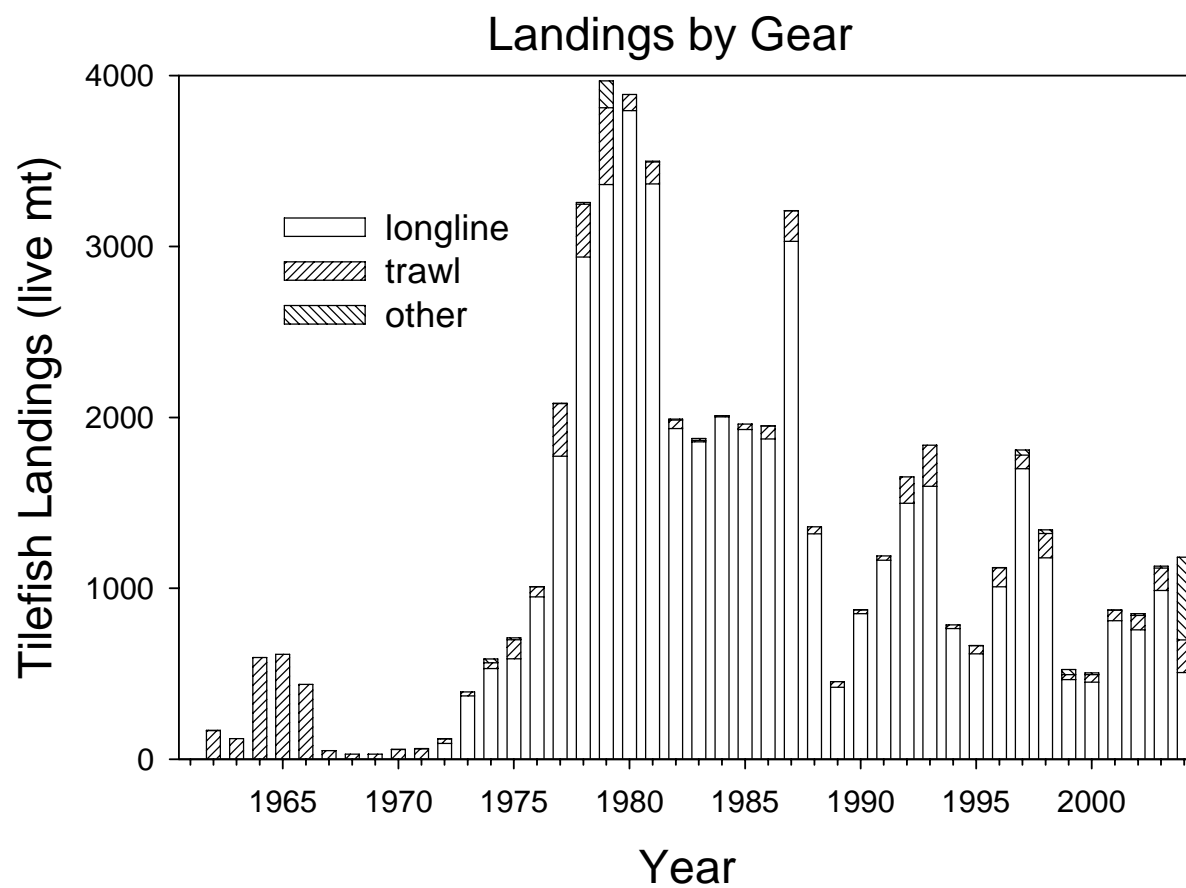
Figure C2. Landings of tilefish (mt, live) by gear. Landing berfore 1990 are from the general canvas data.
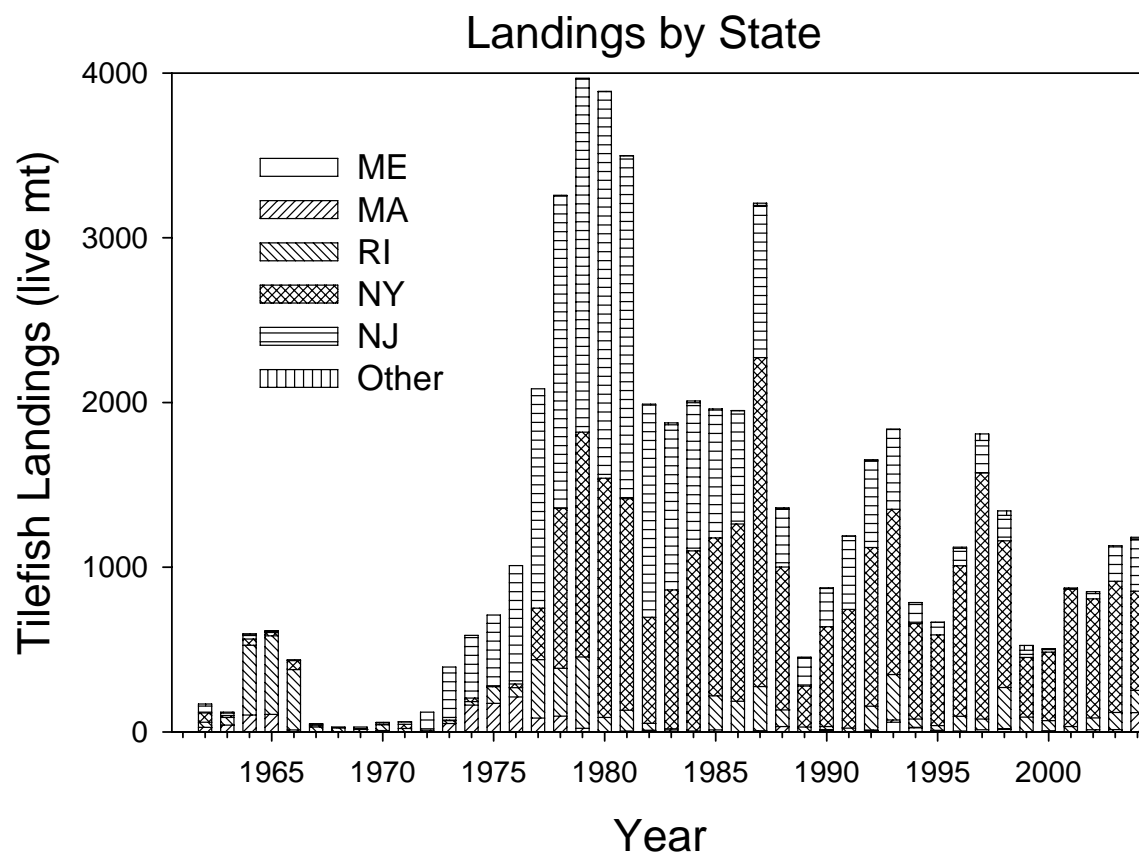
Landings by State

Figure C3. Landings of tilefish (mt, live) by State. Landings berfore 1990 are from the general canvas data.
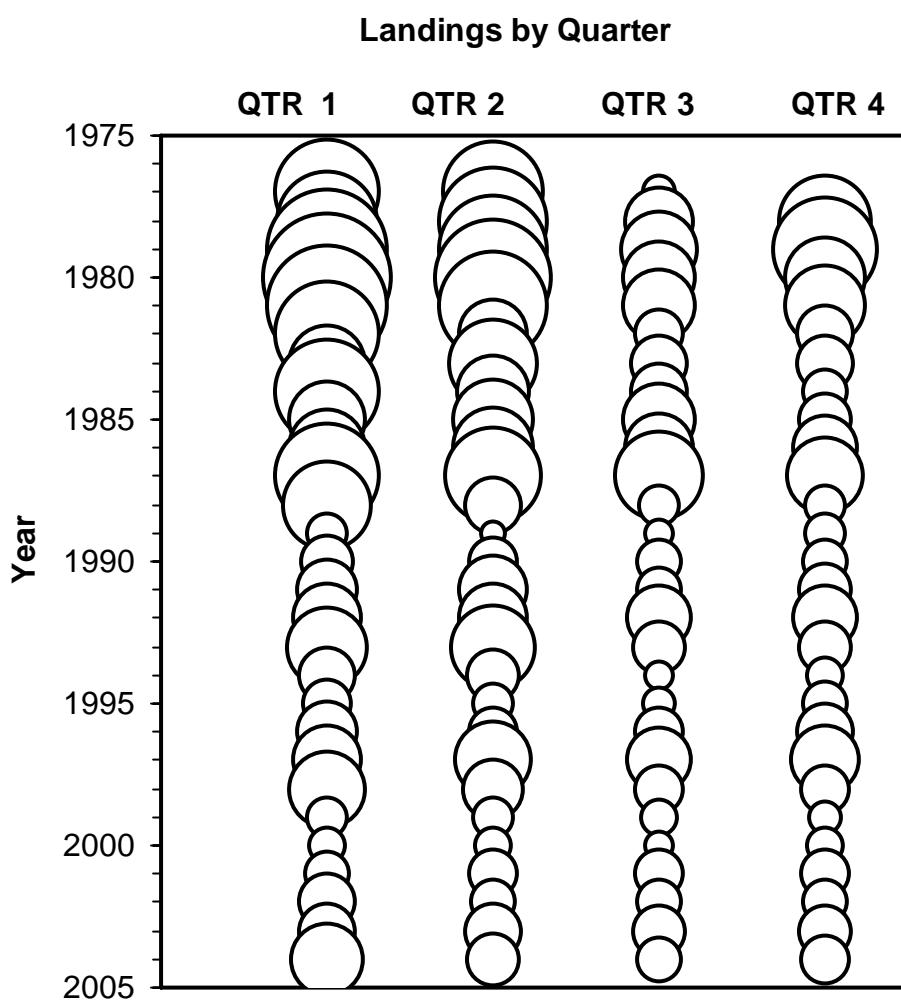
Figure C4. Bubble plot of Golden tilefish landings by quarter.
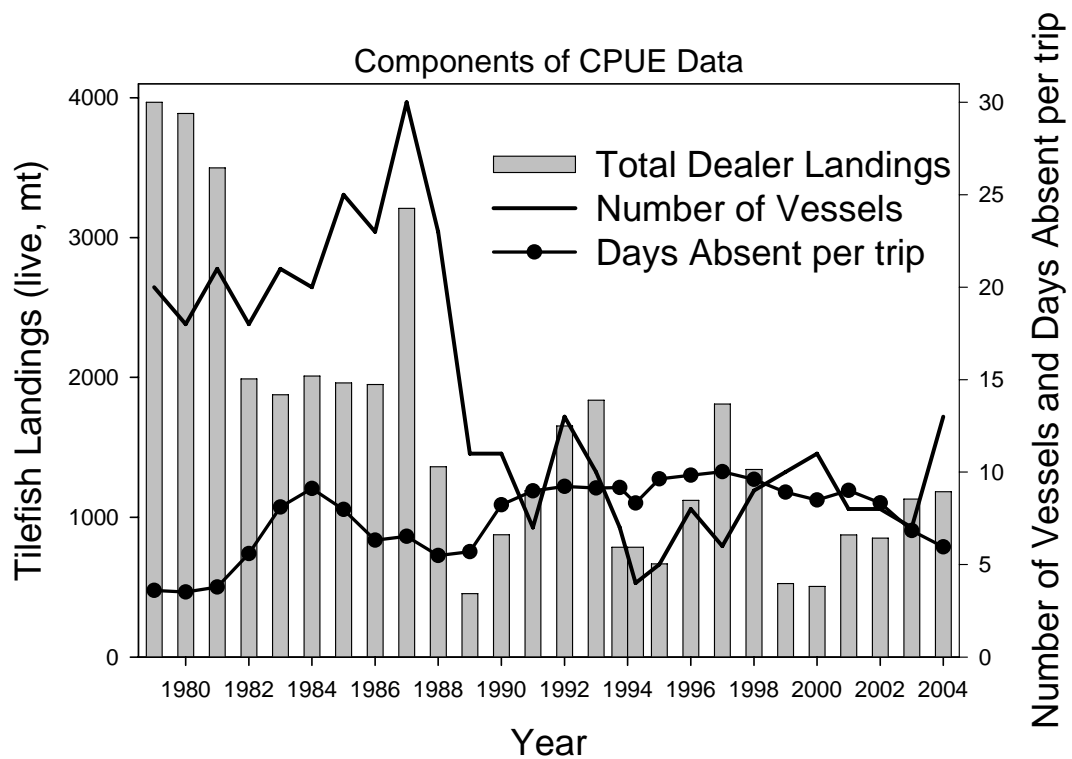
Figure C5. Number of vessels and length of trip (days absent per trip) for trips targeting tilefish (= or >75% tilefish) from 1979-2004. Total Dealer landings are also shown. Year 1994 is split by weighout and VTR data.
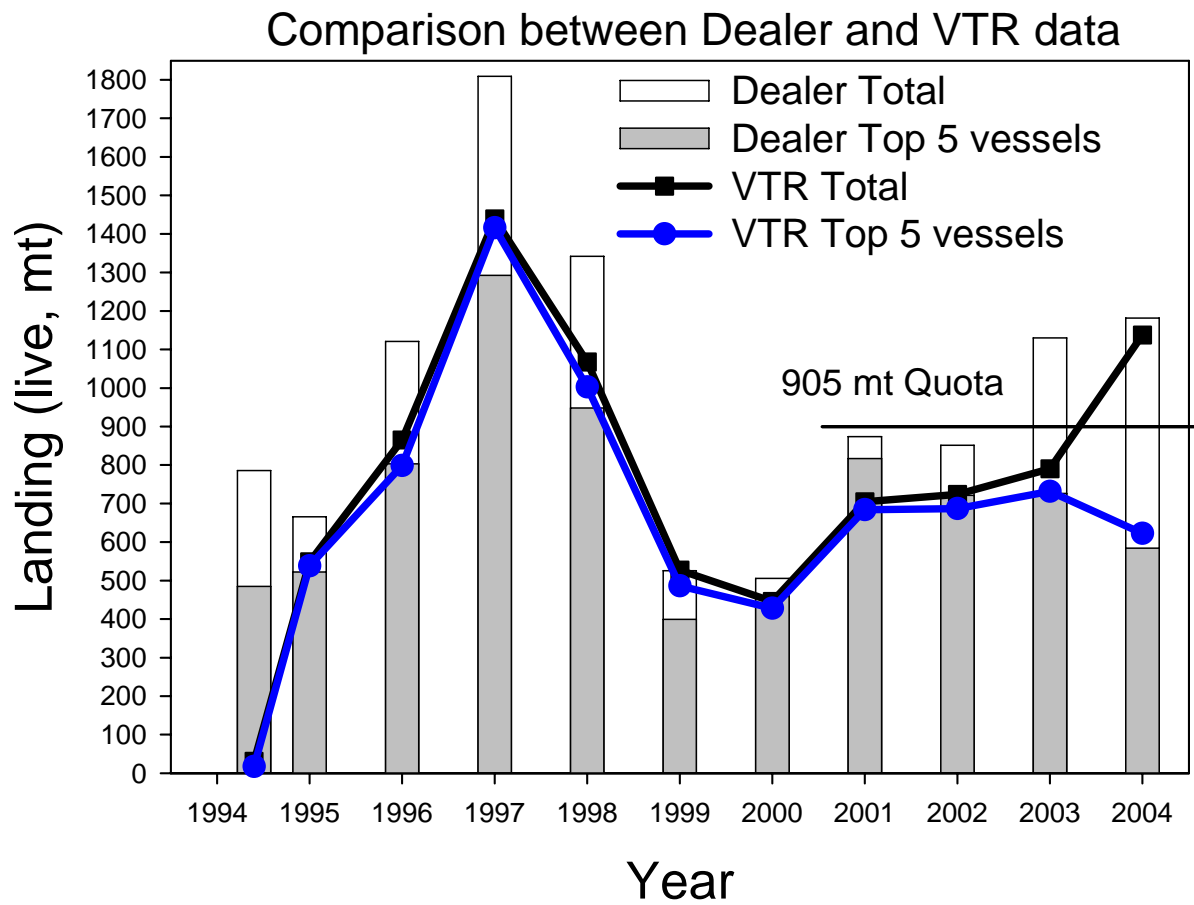
Figure C6. Comparison of dealer and VTR total landings in live metric tons. Total landings limited to the five dominant tilefish vessel are also shown.
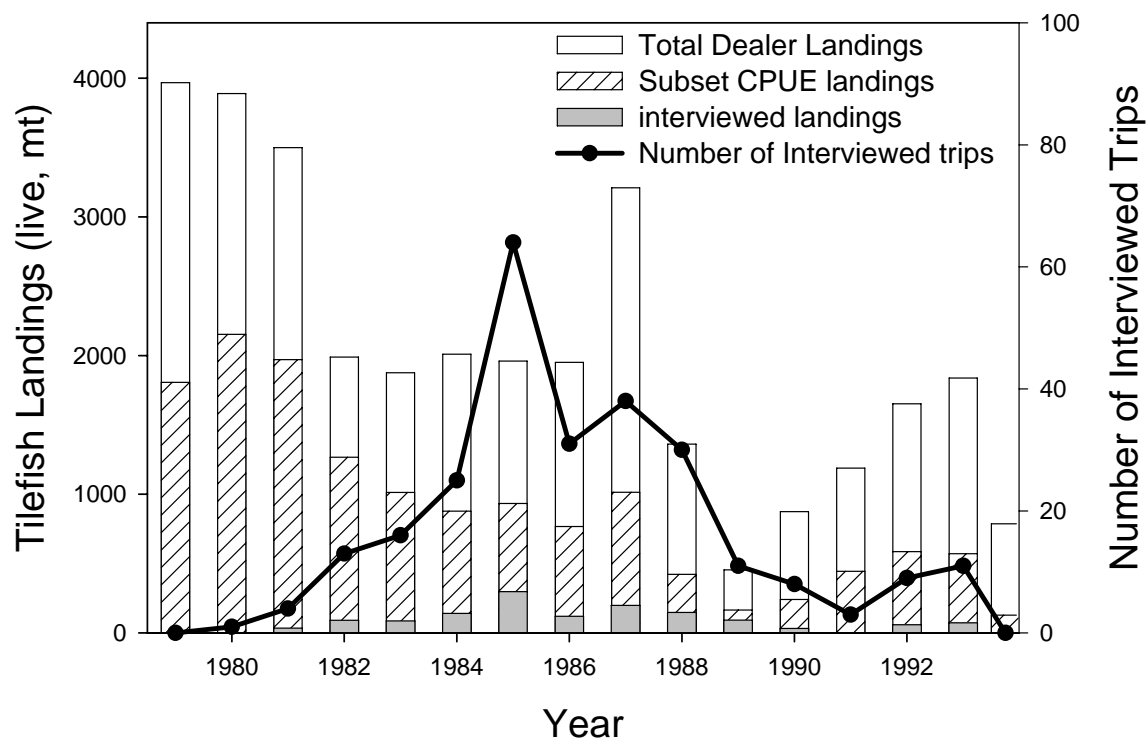
Figure C7. Number of interviewed trips and interviewed landings for trips targeting tilefish (= or >75% tilefish) for the weighout data from 1979-1994. Total weighout landings and the subset landings used in CPUE estimate are also shown.
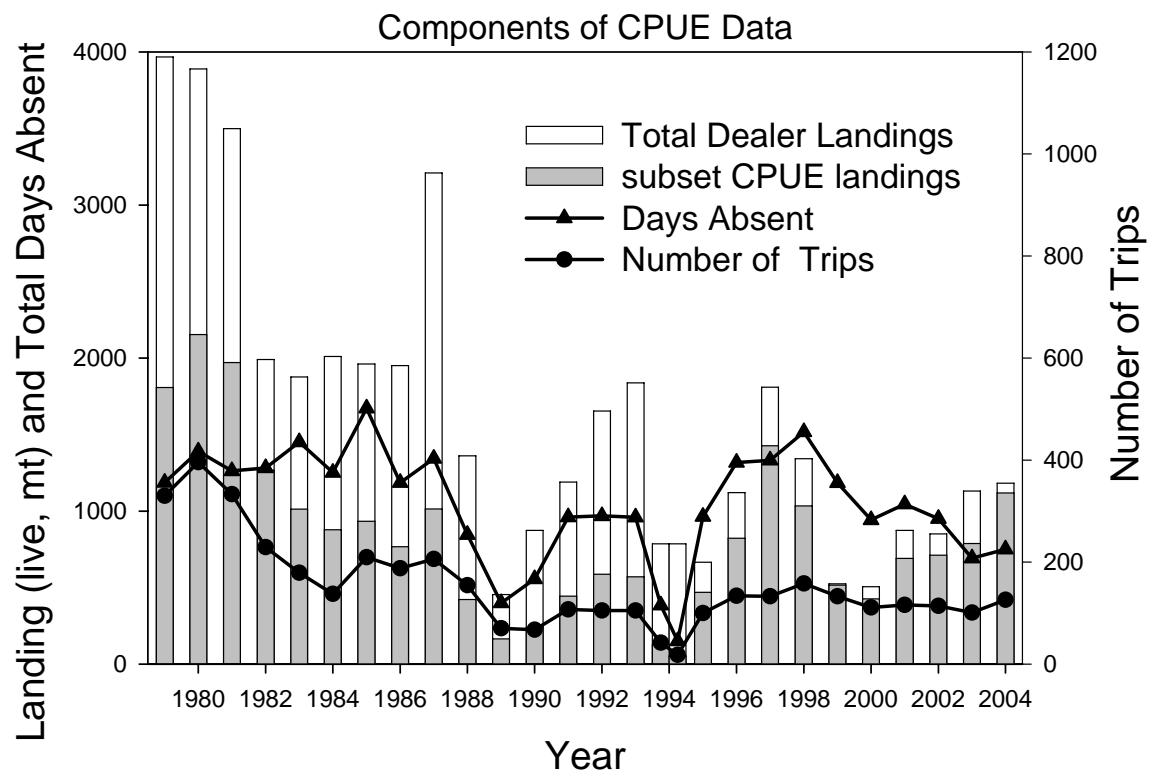
Figure C8. Total number of trips and days absent for trips targeting tilefish (= or >75% tilefish) from 1979-2004. Total Dealer and CPUE subset landings are also shown. Year 1994 is split by weighout and VTR data.
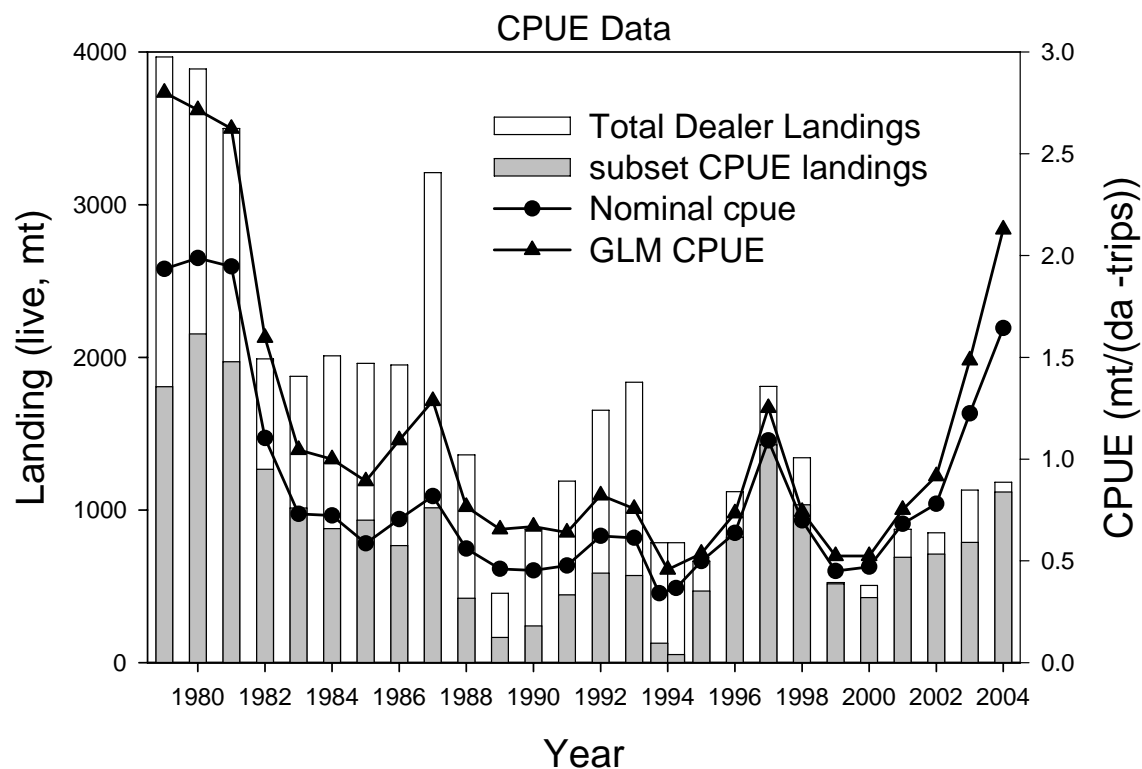
Figure C9. Nominal CPUE (1994 split by weighout and VTR series) and vessel standardized CPUE (GLM) for trips targeting tilefish (= or >75% tilefish) from 1979-2004. Total Dealer and CPUE subset landings are also shown. Year 1994 is split by the weighout and VTR data for the landings and nominal CPUE series.
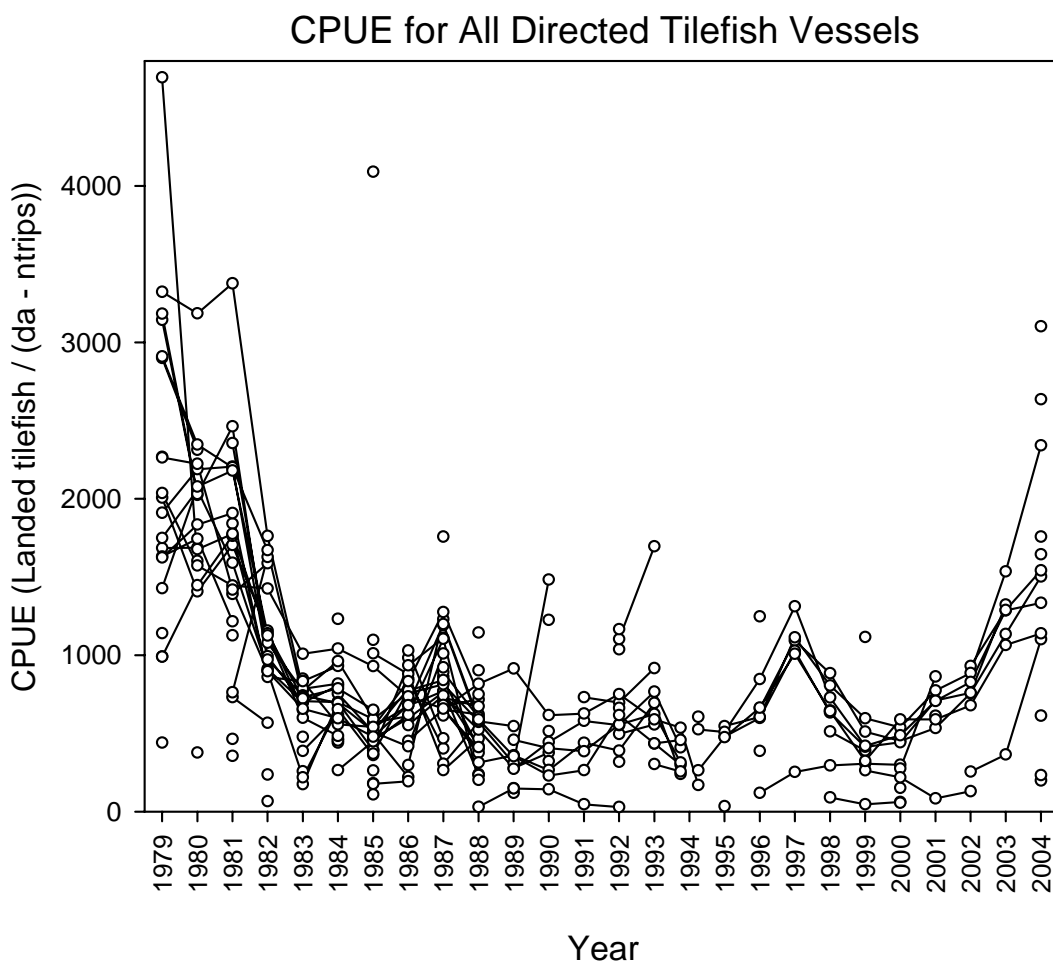
Figure C10. All individual tilefish vessel CPUE data for trips targeting tilefish (= or >75% tilefish) from 1979-2004.
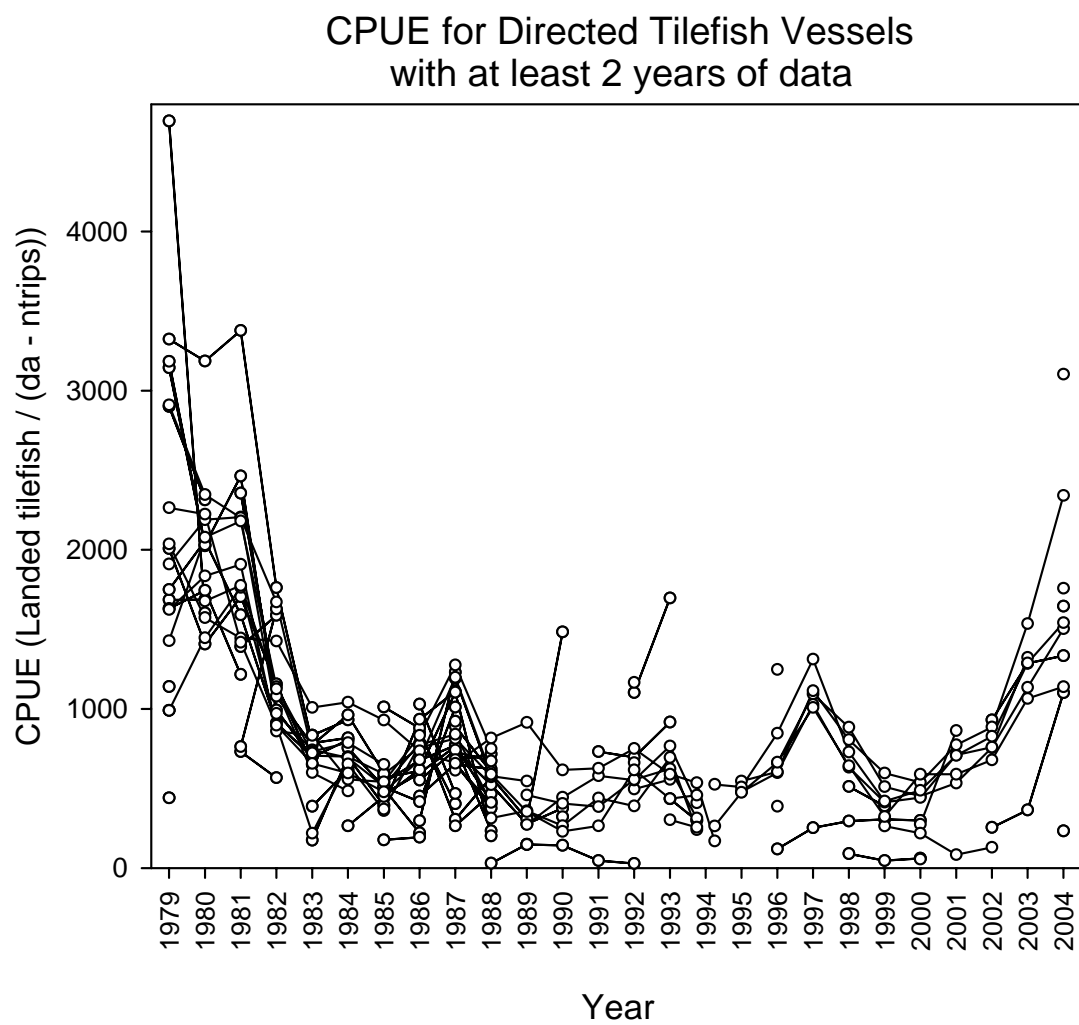
Figure C11. Individual tilefish vessel CPUE data for trips targeting tilefish
(= or >75% tilefish) from 1979-2004 with at least 2 years of data.

CPUE for Directed Tilefish Vessels
with at least 3 years of data
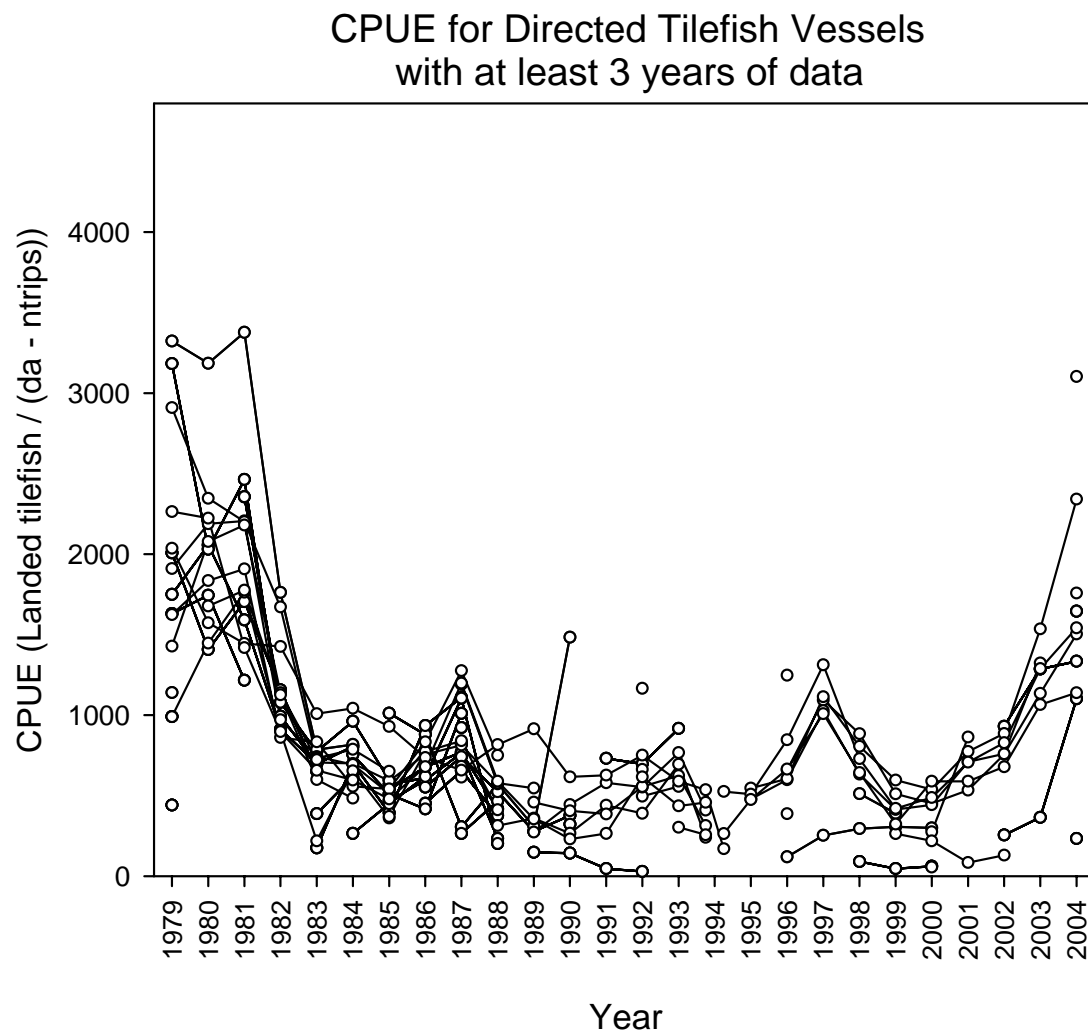
Figure C12. Individual tilefish vessel CPUE data for trips targeting tilefish
(= or >75% tilefish) from 1979-2004 with at least 3 years of data.
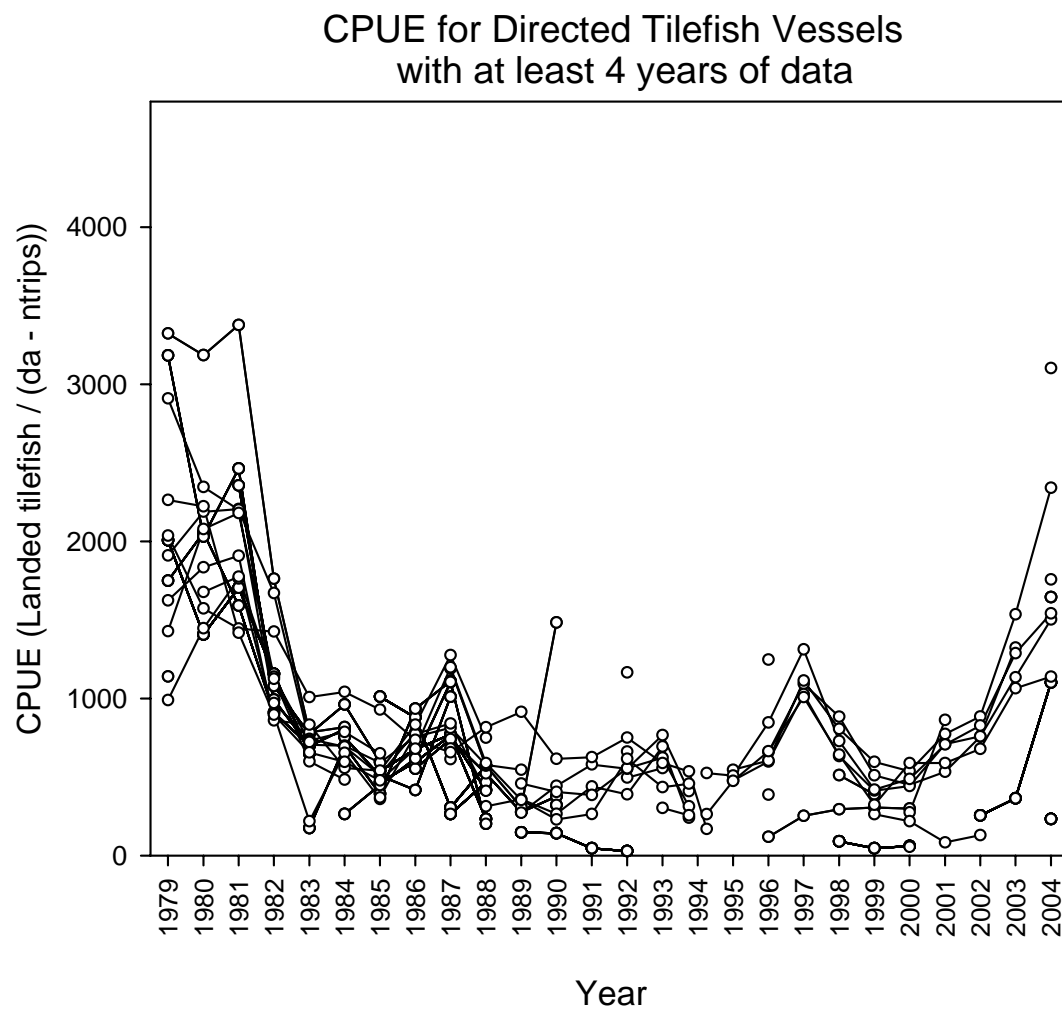
Figure C13. Individual tilefish vessel CPUE data for trips targeting tilefish (= or >75% tilefish) from 1979-2004 with at least 4 years of data.
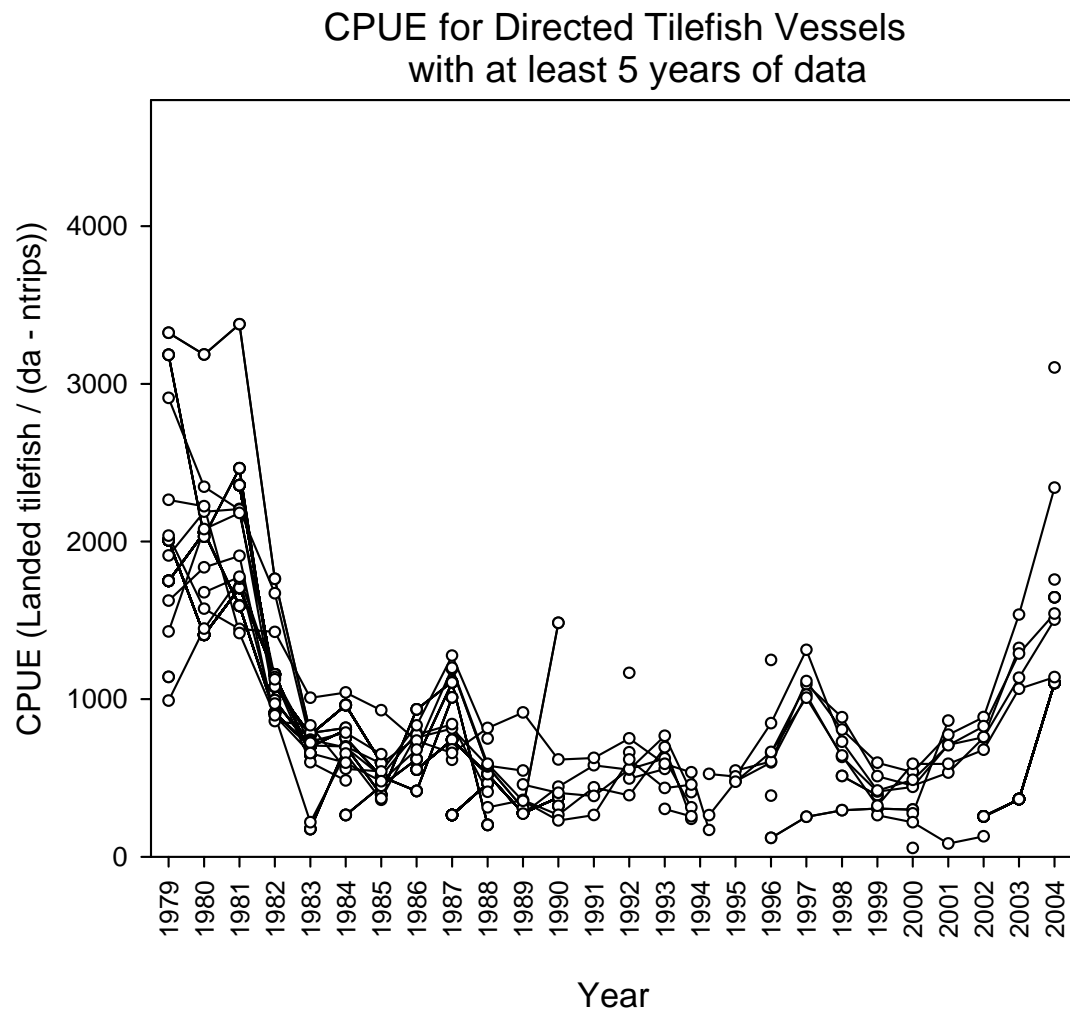
Figure C14. Individual tilefish vessel CPUE data for trips targeting tilefish (= or >75% tilefish) from 1979-2004 with at least 5 years of data.

# CPUE for Directed Tilefish Vessels
with at least 6 years of data
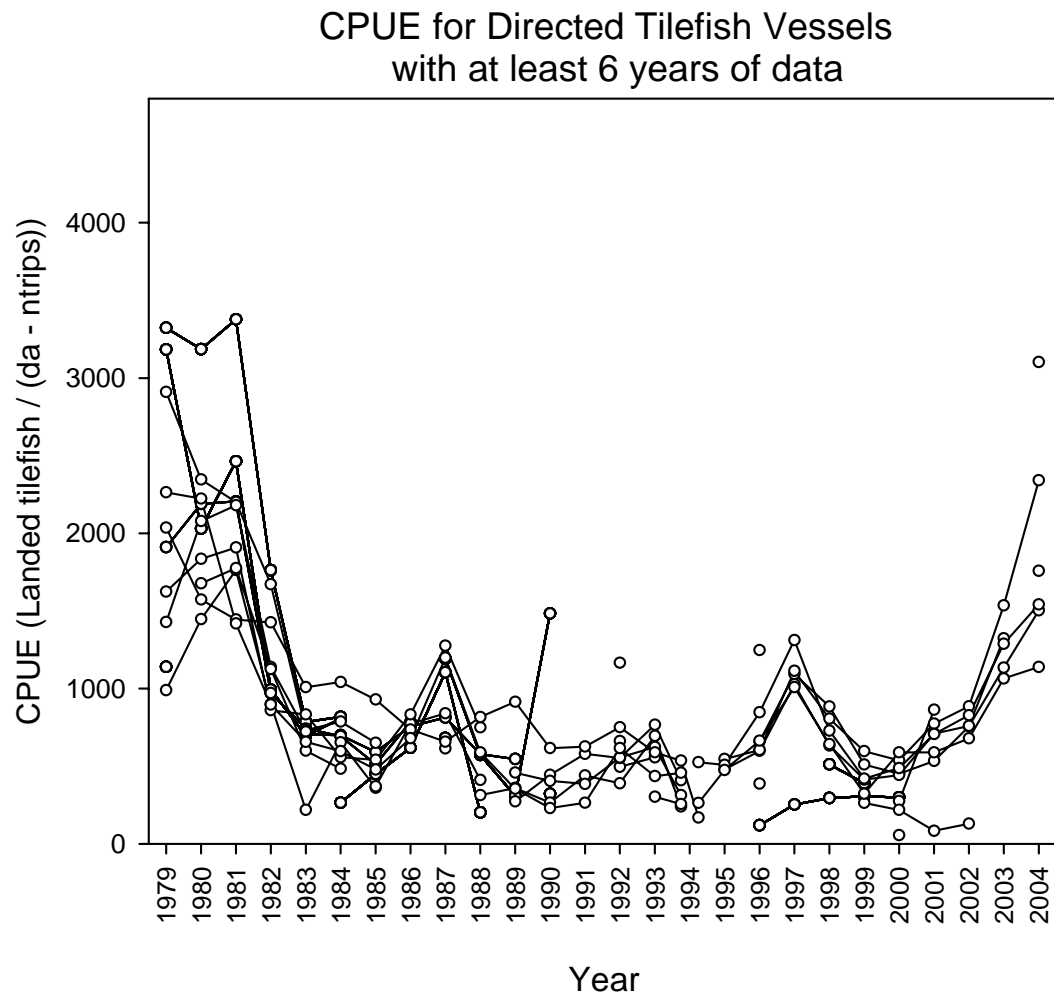
Figure C15. Individual tilefish vessel CPUE data for trips targeting tilefish
(= or >75% tilefish) from 1979-2004 with at least 6 years of data.
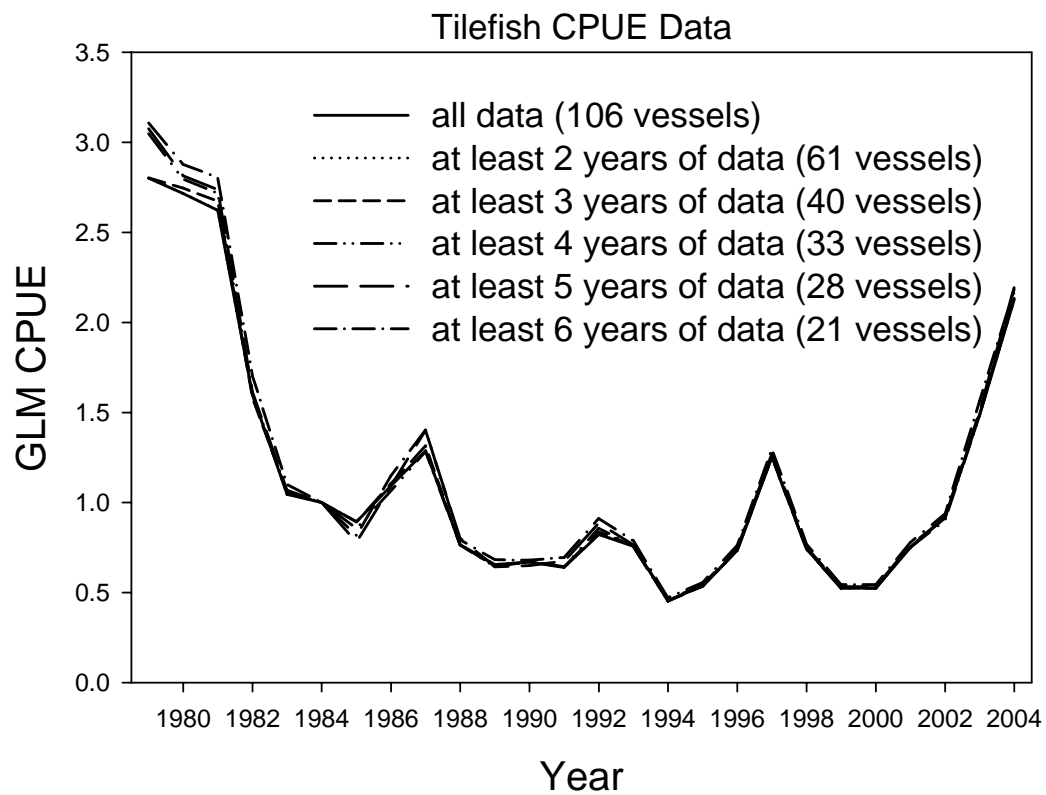
Figure C16. Sensitivity of the GLM (weighout and VTR combined) to the triming of vessels with different amonts of data.

Figure C17. Depiction of individual vessels (rows) targeting tilefish over the weighout and VTR series. Year 1994 is split by the two series. Below the horizontal line are vessels which are predominantly found in the VTR series.
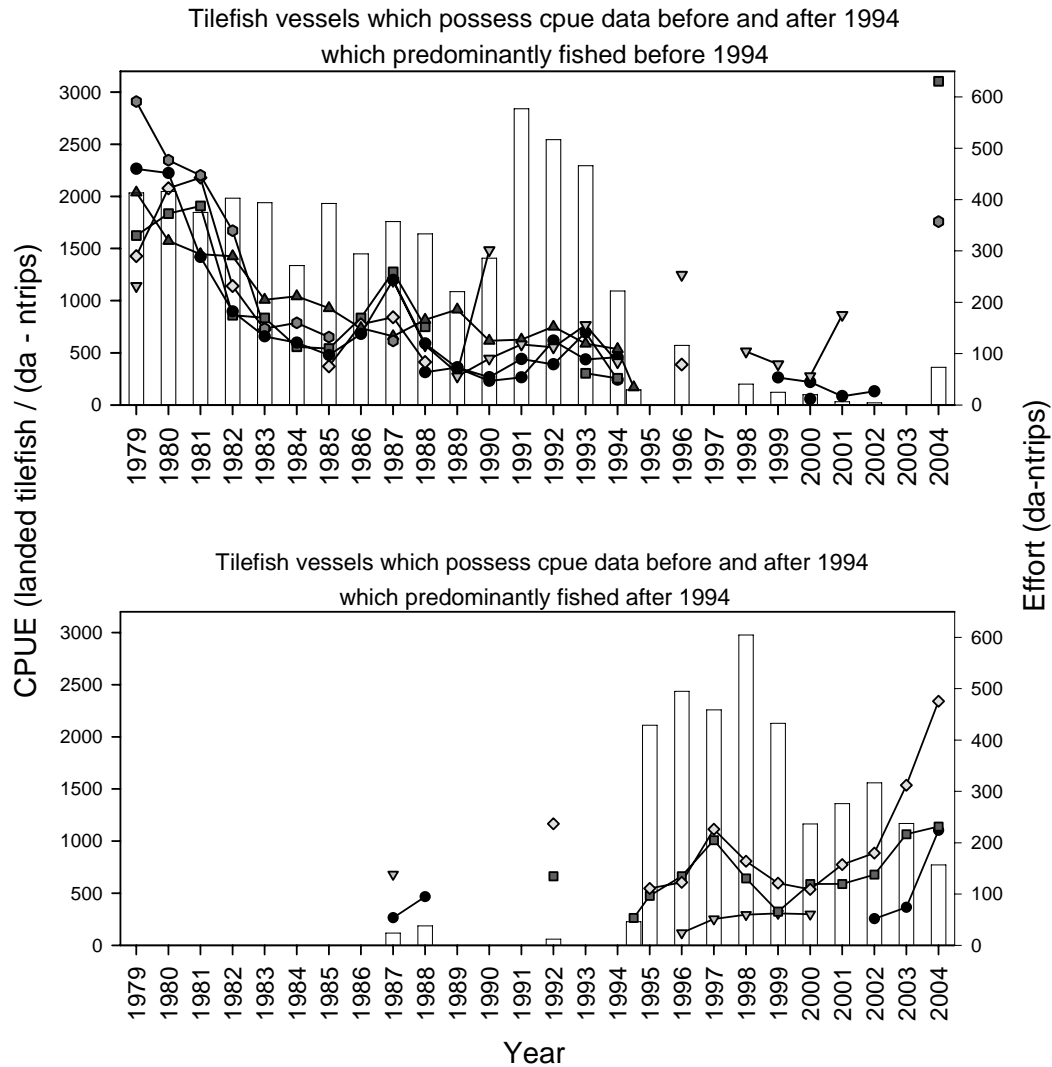
Figure C18. Individual tilefish vessel CPUE and effort data (Bars) for trips targeting tilefish (= or >75% tilefish) from 1979-2004 which are found in both the weighout and VTR series. Top graph are vessels found predominantly in the weighout series. Bottom graph are vessels found predominantly in the VTR series.
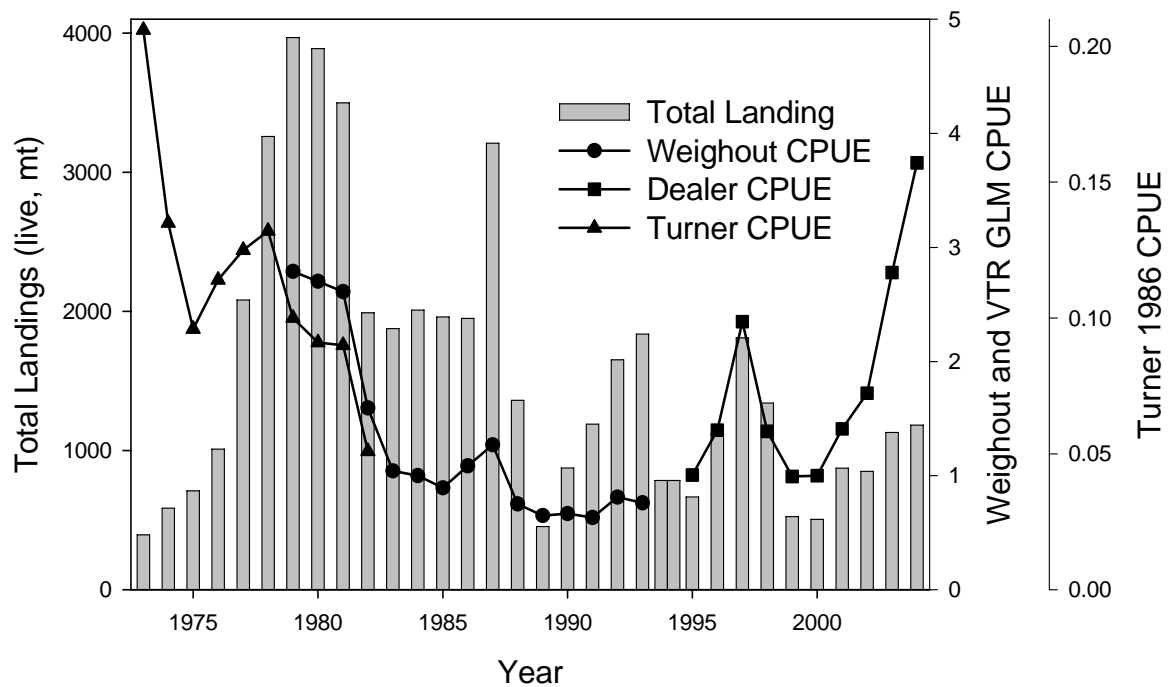
Figure C19. GLM CPUE for the weighout and VTR data split into two series. Four years of overlap between Turner and the weighout CPUE series can be seen. Total Dealer landings are also shown.
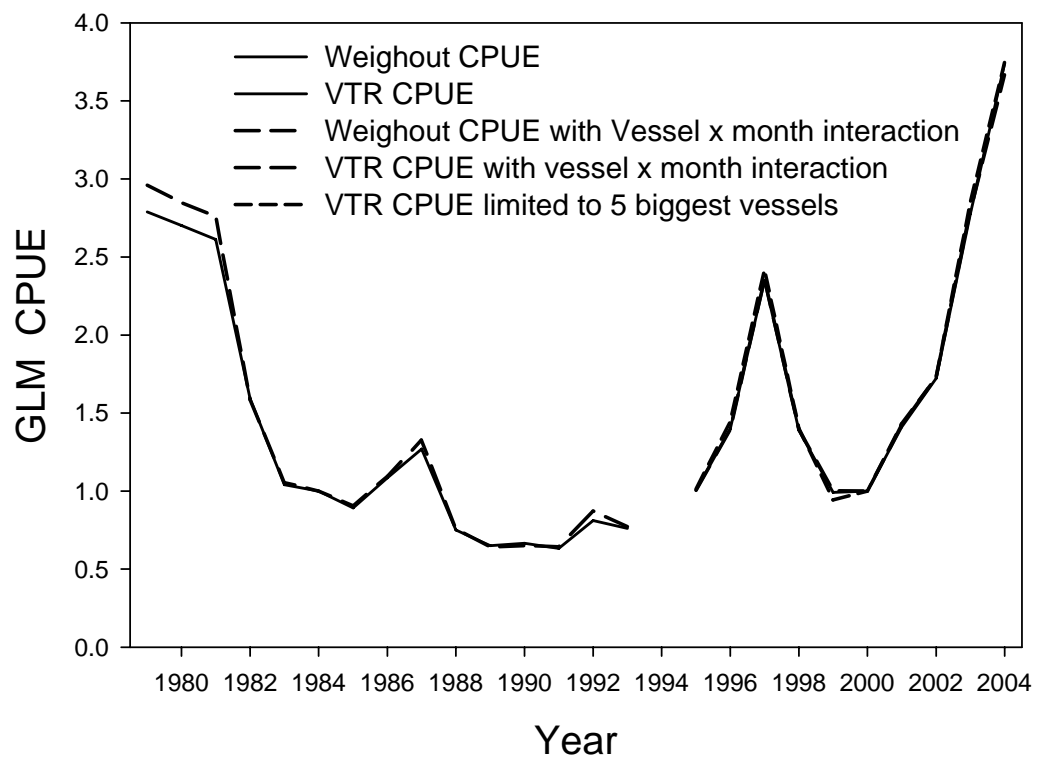
Figure C20. Standardized CPUE (GLM) data with the weighout and VTR data split into two series. GLM CPUE estimates with vessel-month interaction and a GLM limited to the five dominant vessels for the VTR data are also shown.
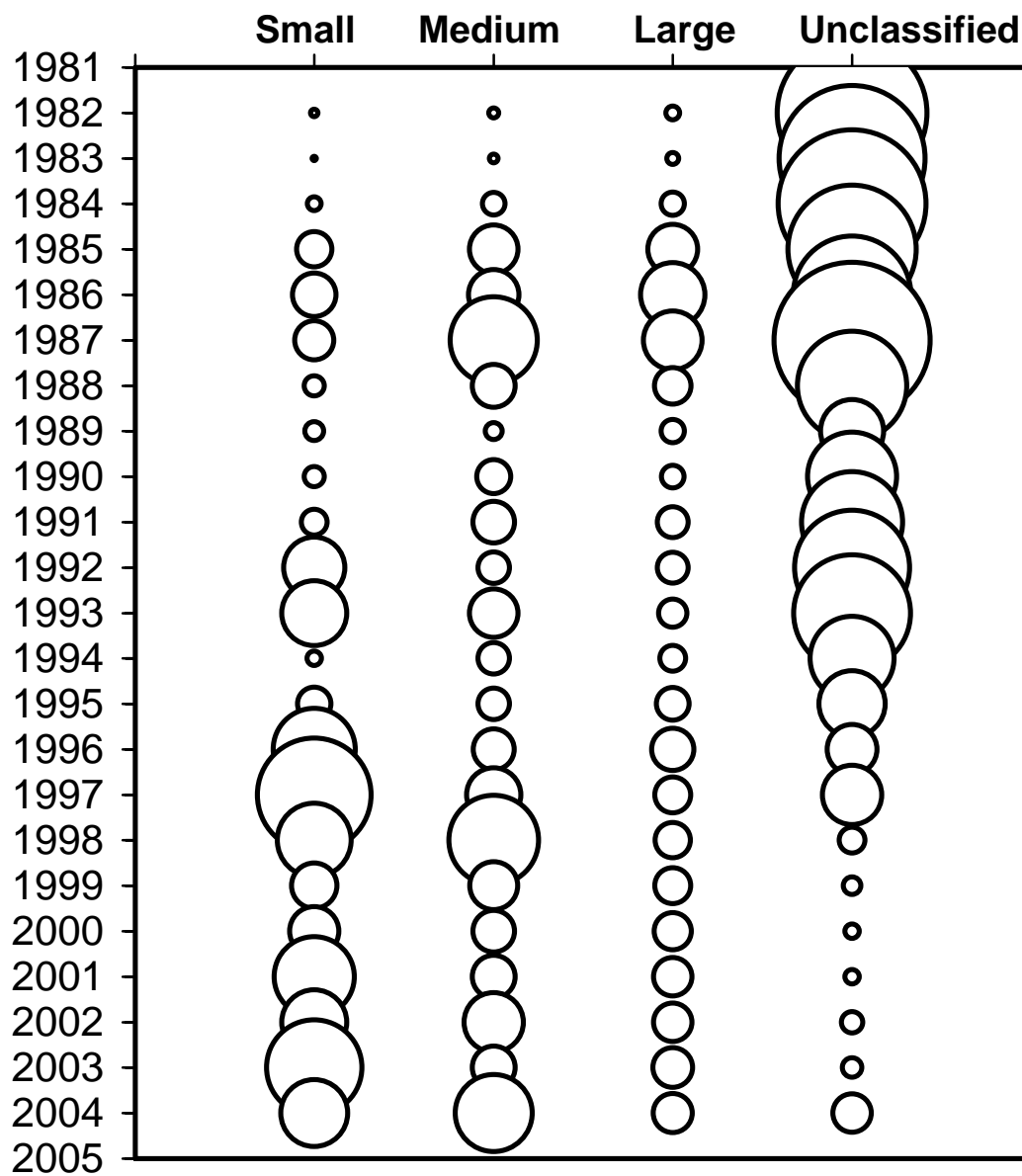
Figure C21. Bubble plot of Golden tilefish landings by market category.

Percent landings by Market category
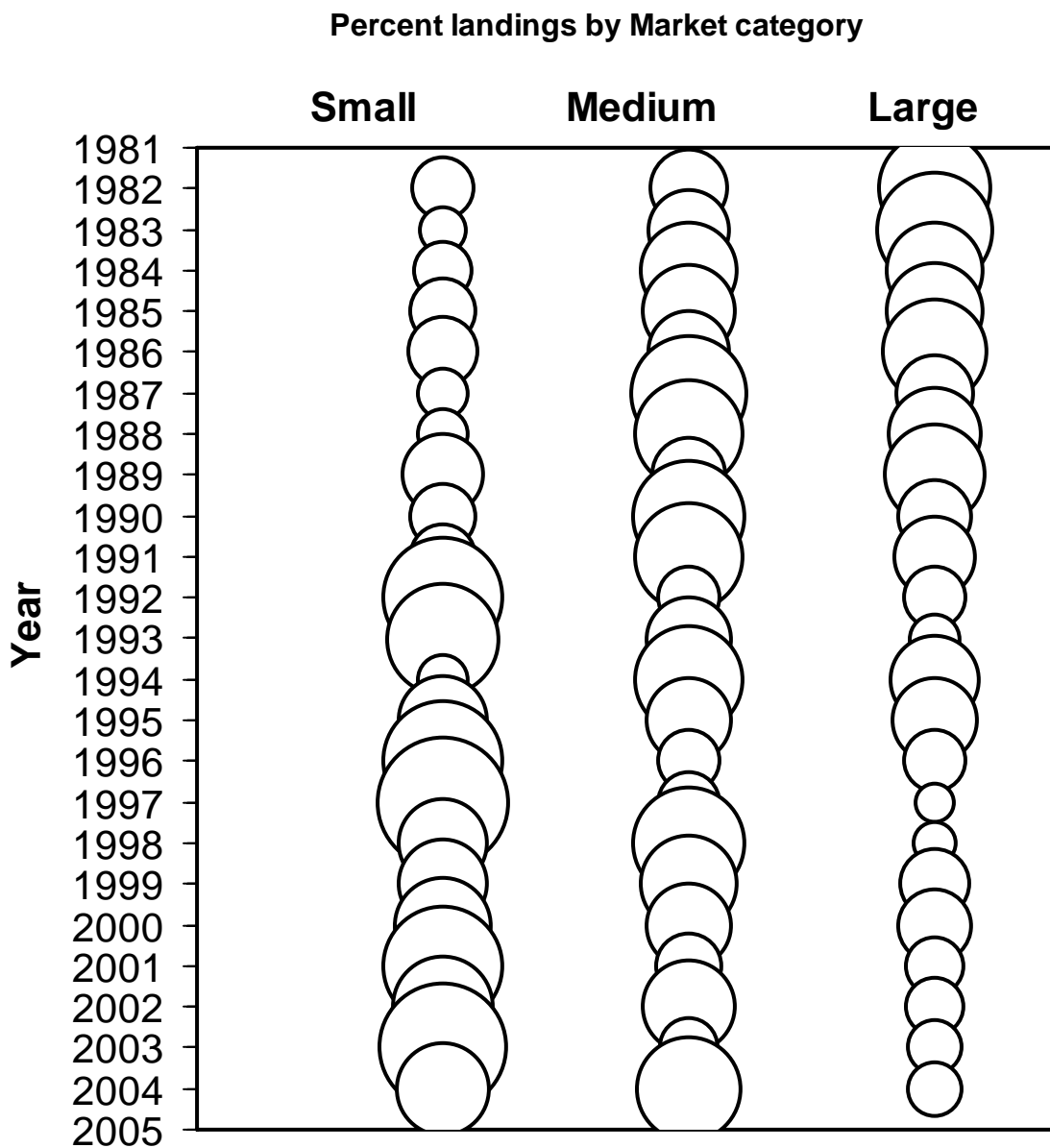
Figure C22. Bubble plot of percent Golden tilefish landings by market category.

Unclassified landings were redistributed according to the other market categories.
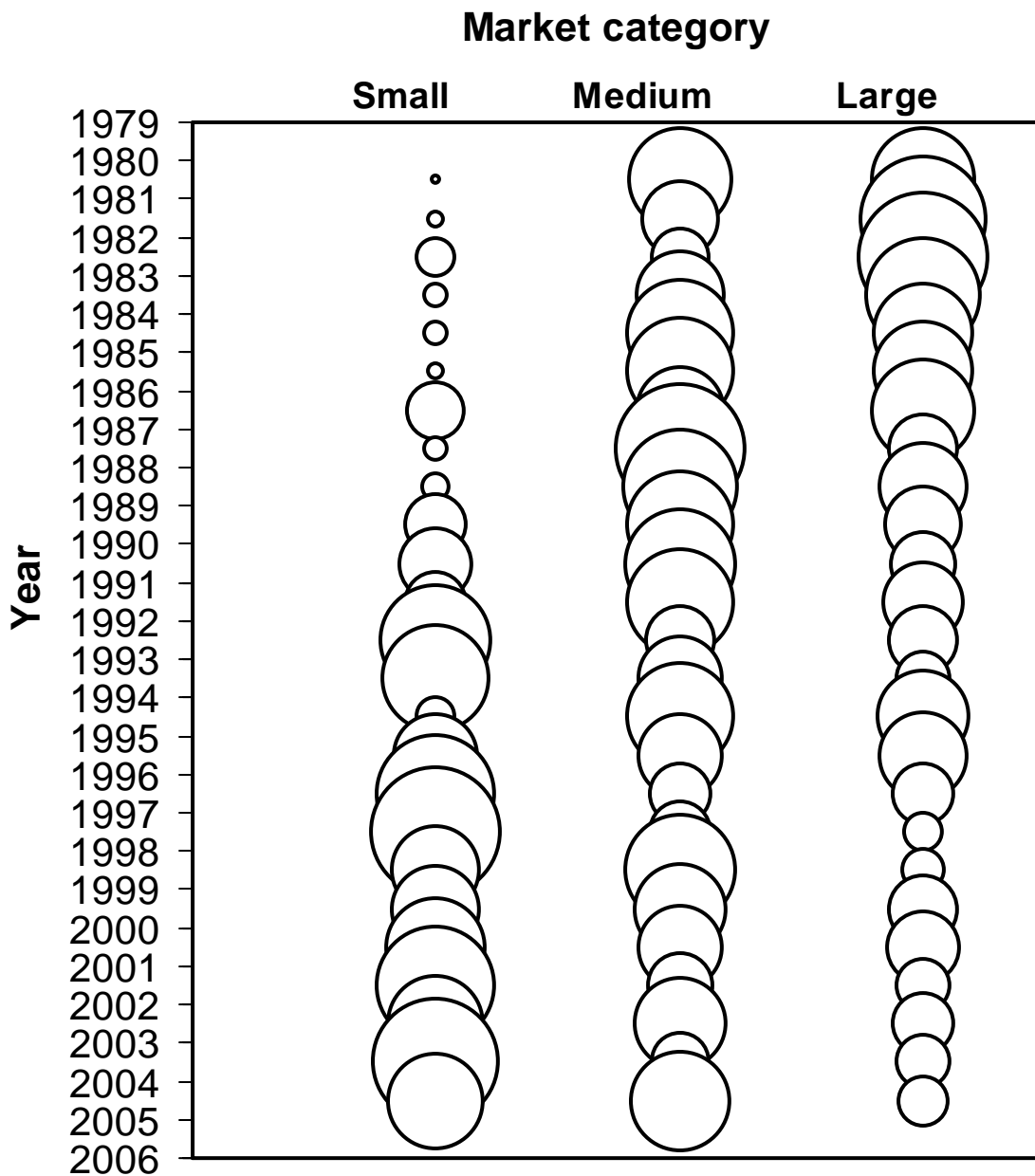
Market category

Figure C23. Bubble plot of percent Golden tilefish longline landings by market category. Data from 1980 to 1990 comes from New York tilefish fishermen. Data form 1991-2003 was taken from the dealer data. Data form 2004 are from dealer electronic reporting. Unclassified landings were redistributed according to the other market categories.
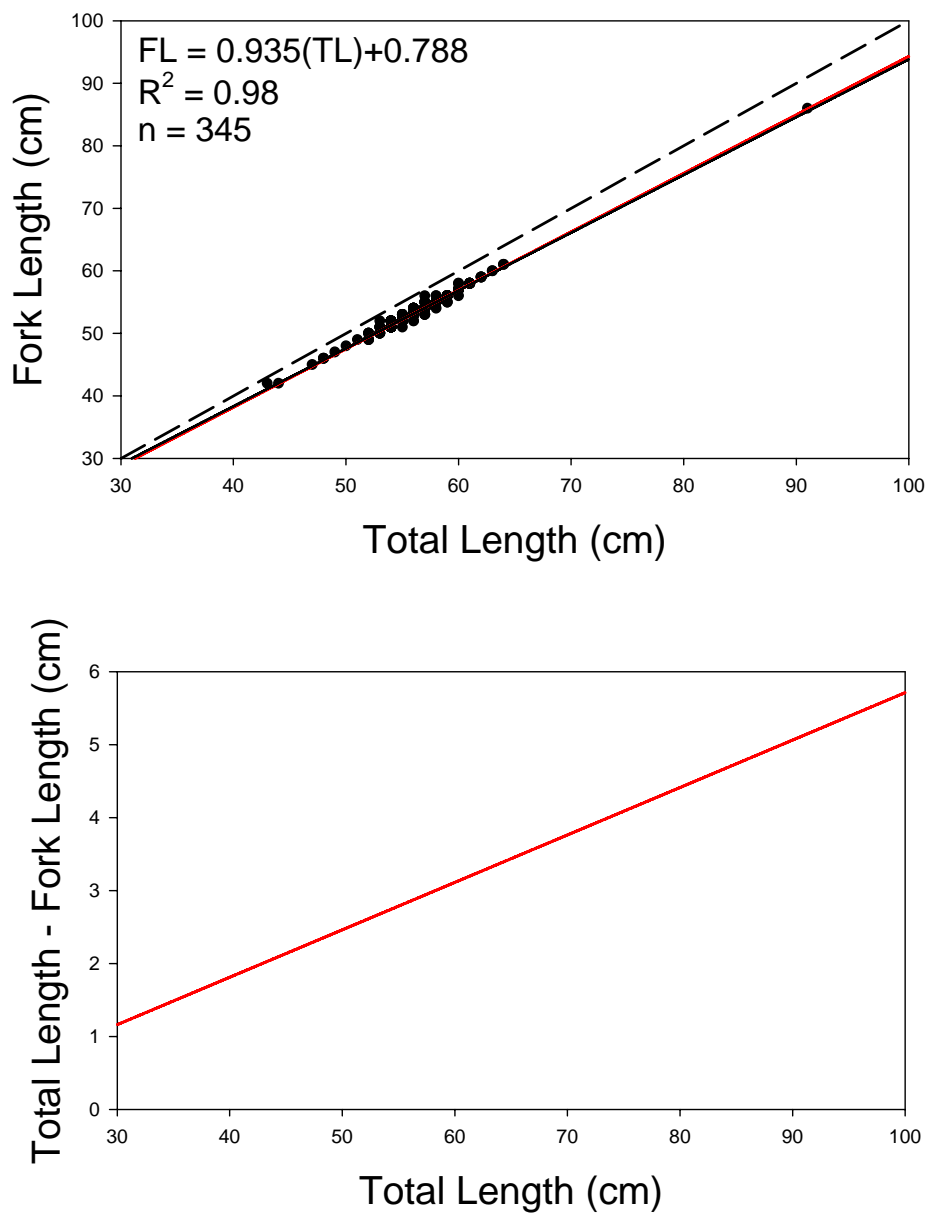
Figure C24. Top graph shows the estimated regression between total and fork length for Golden tilefish for data collected in 2005. Bottom graph illustrates the difference between the two measurements.
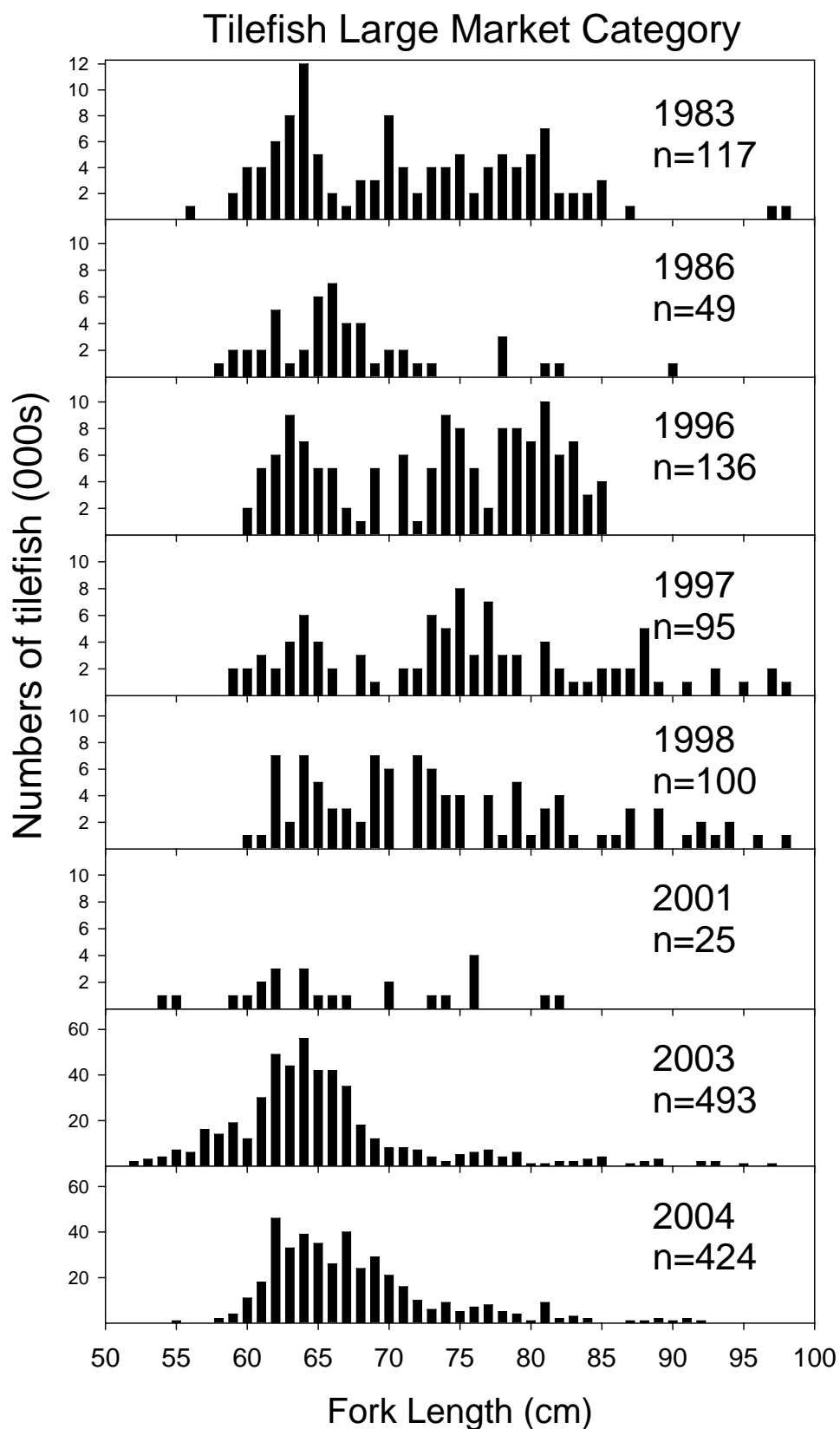
Figure C25. Large tilefish market category length frequency distributions by year. Lengths from New York from 2000 to 2004 were converted to fork length.

Tilefish Medium Market Category
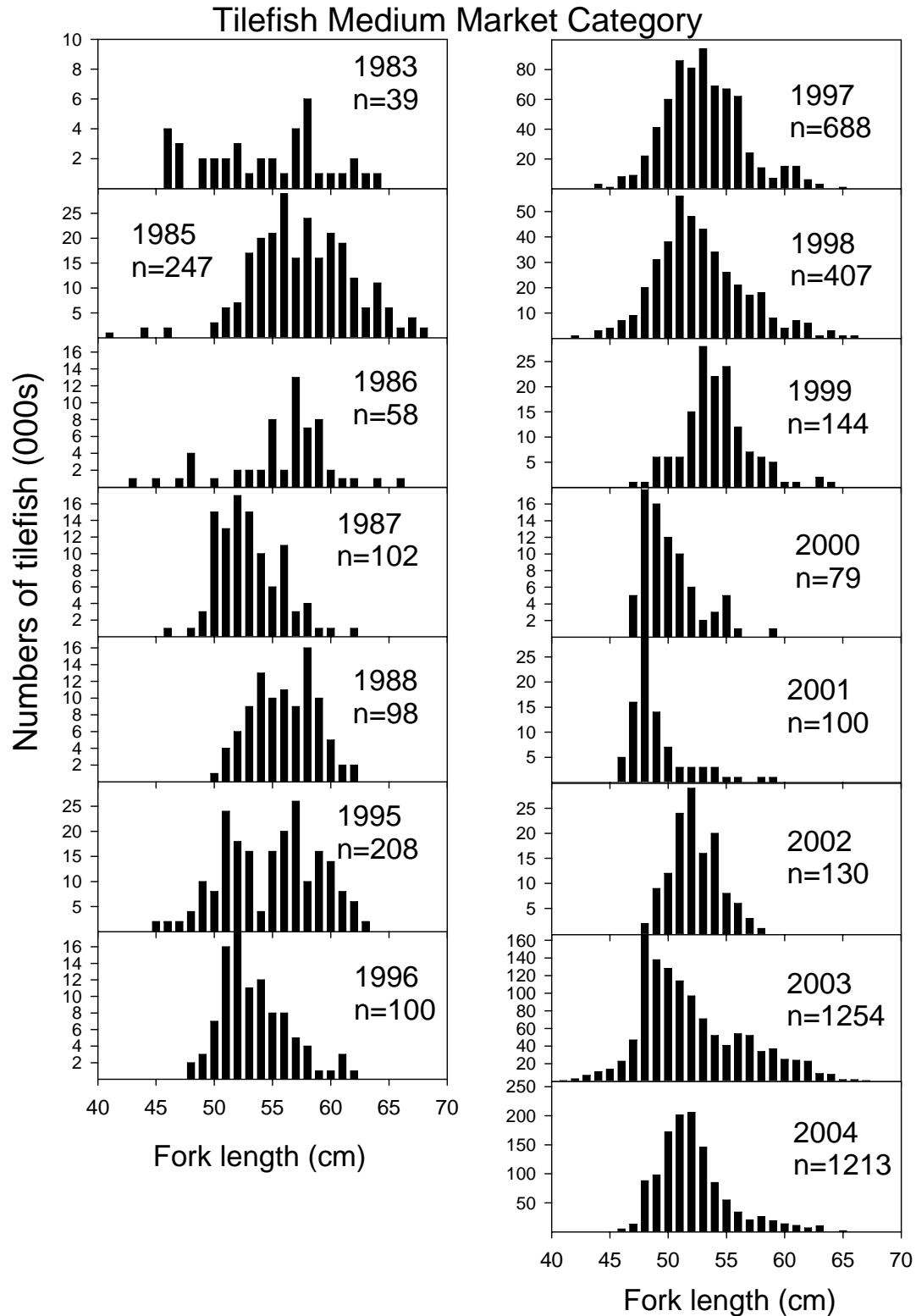
Figure C26. Medium tilefish market category length frequency distributions by year. Lengths from New York from 2000 to 2004 were converted to fork length.

Tilefish Small Market Category
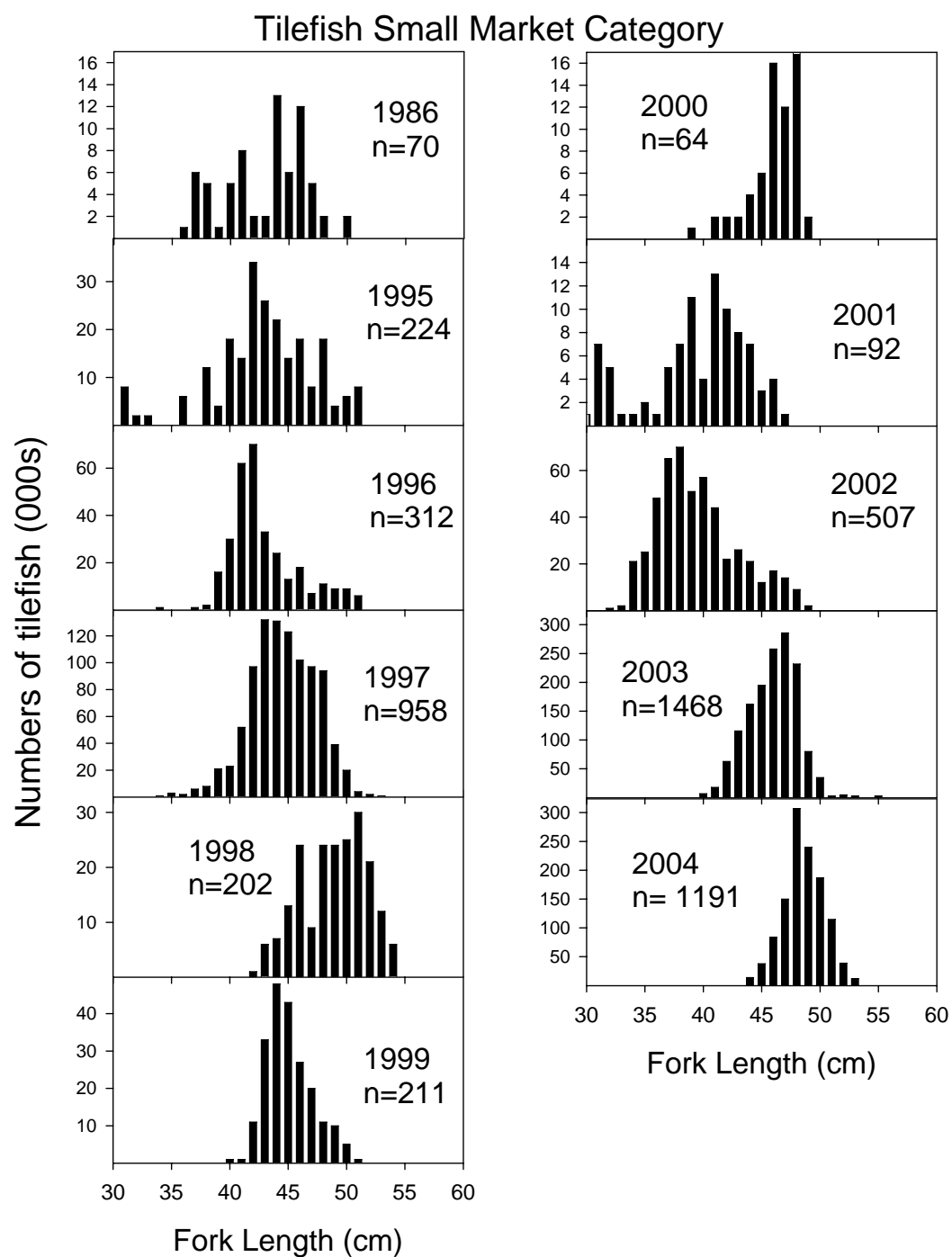
Figure C27. Small tilefish market category length frequency distributions by year. Lengths from New York from 2000 to 2004 were converted to fork length.

Tilefish Market Category by QTR

Small

Medium

Numbers of tilefish (000s)

2002 Q1
n=127

2002 Q1
n=130

2002 Q3
n=217

2002 Q4
n=163

2003 Q1
n=104

2003 Q1
n=189

2003 Q2
n=200

2003 Q2
n=207

2003 Q3
n=832

2003 Q3
n=489

2003 Q4
n=332

2003 Q4
n=369

2004 Q1
n=550

2004 Q1
n=667

2004 Q2
n=338

2004 Q2
n=214

2004 Q3
n=205

2004 Q3
n=218

2005 Q4
n=98

2005 Q4
n=114
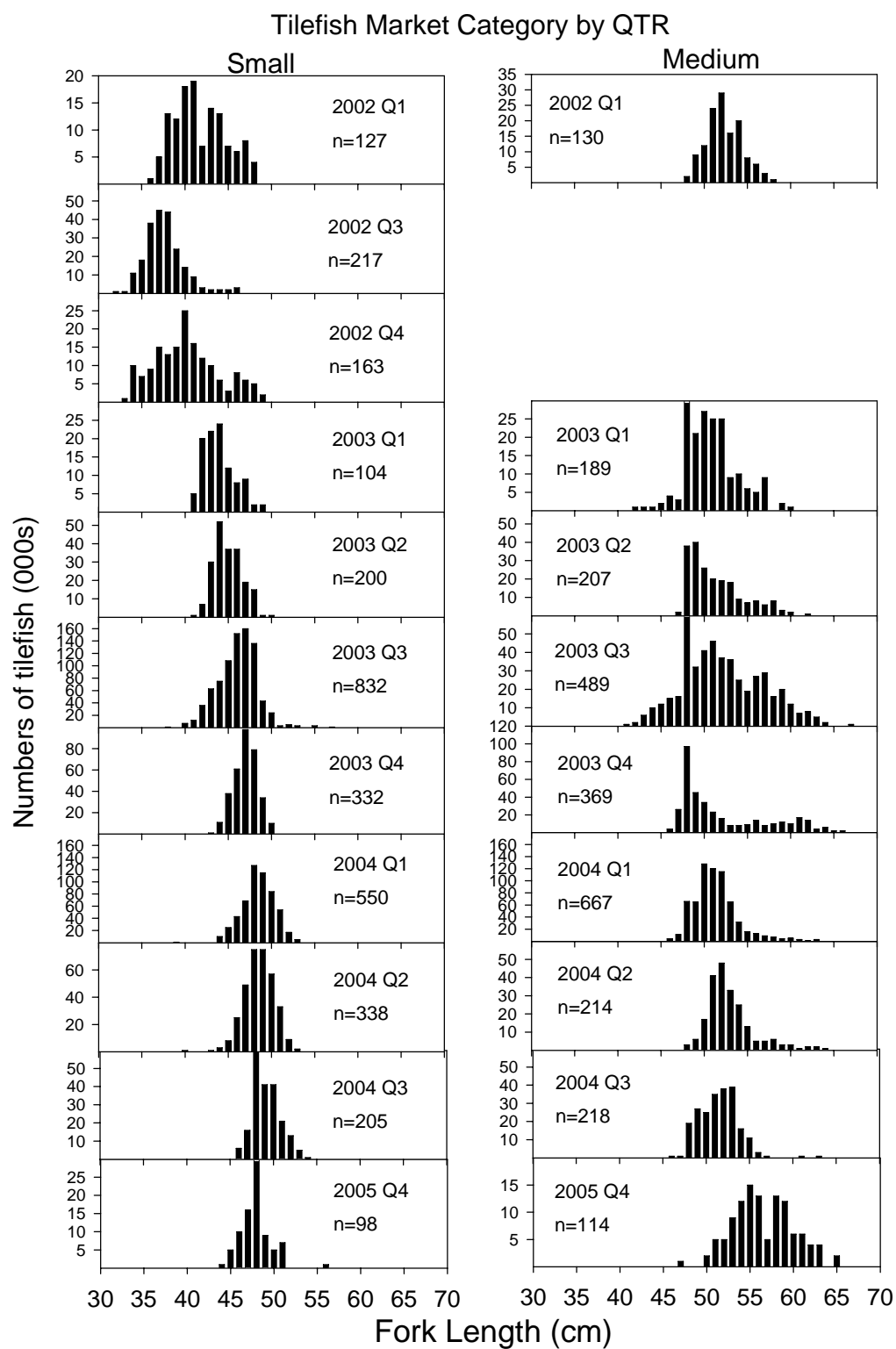
Fork Length (cm)

Figure C28. Small and medium tilefish market category length frequency distributions by quarter. Lengths from New York from 2000 to 2004 were converted to fork length.

Tilefish Trawl small Market Category
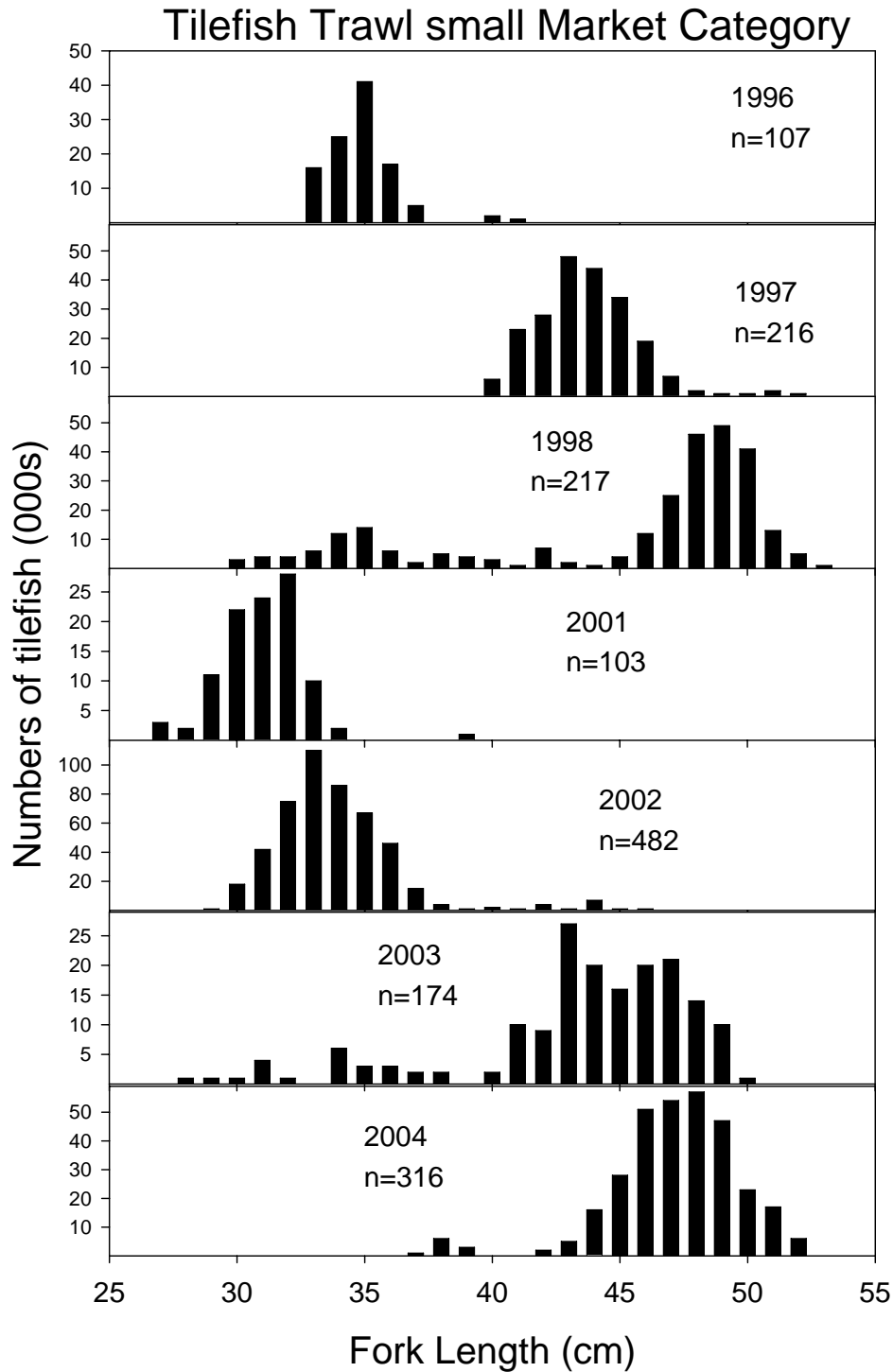
Figure C29. Trawl small tilefish market category length frequency distributions by year. Lengths from New York from 2000 to 2004 were converted to fork length.
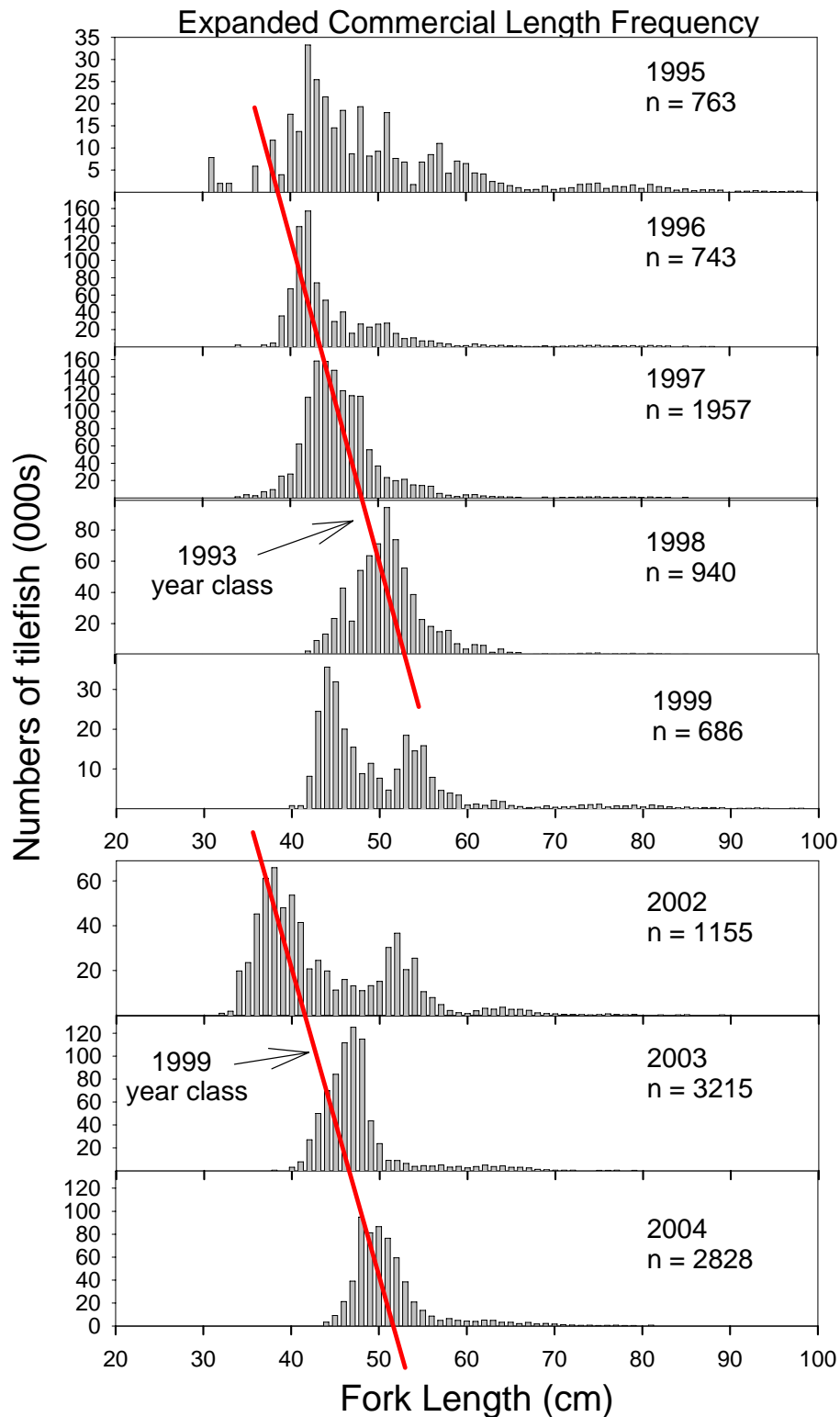
Figure C30. Expanded catch length frequency distributions by year. Large market category lengths used from 1995 to 1999 were taken from years 1996, 1997, and 1998. Large lengths for 2002 when taken from large lengths in 2001 and 2003.
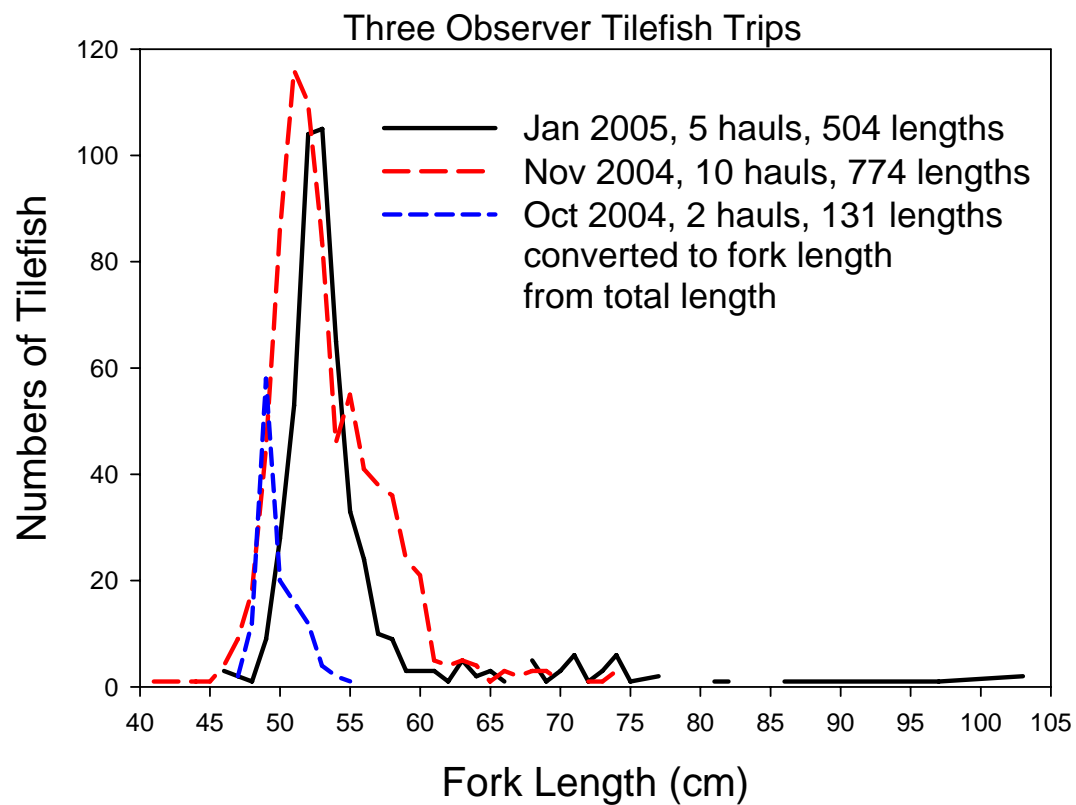
Figure C31. Observer Length frequency distributions from three longline tilefish trips.

Individual year data

Observer Length Data
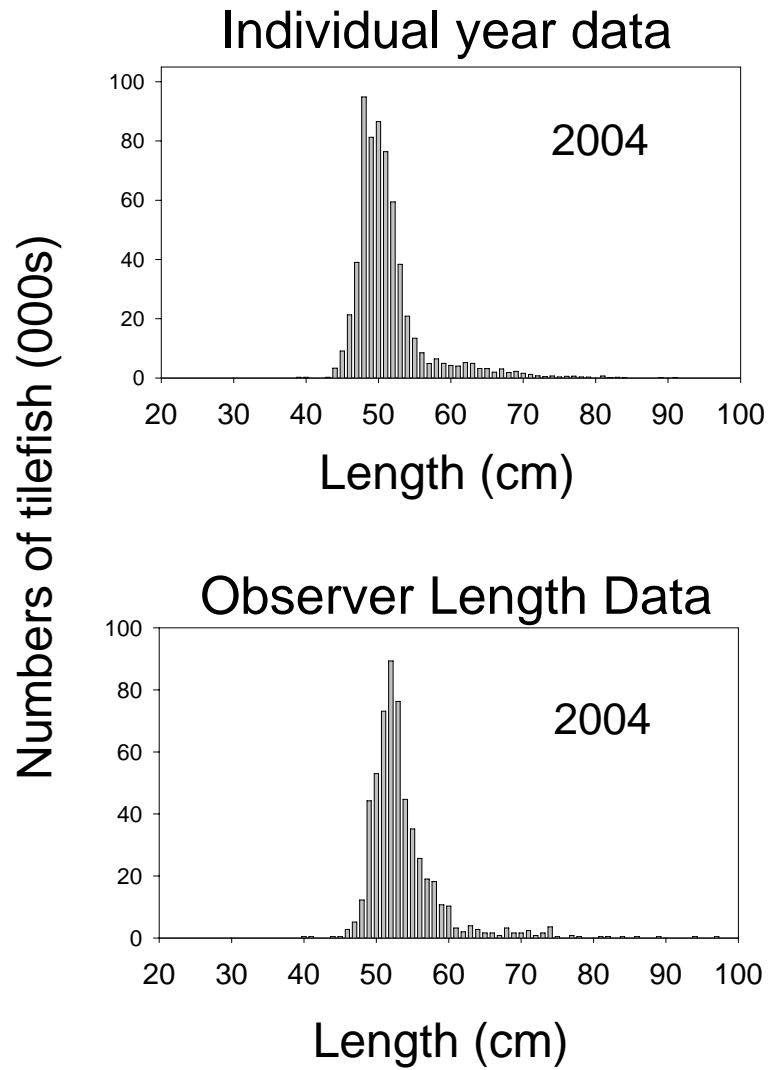
Figure C32. Comparison of expanded length frequency distributions for 2004.
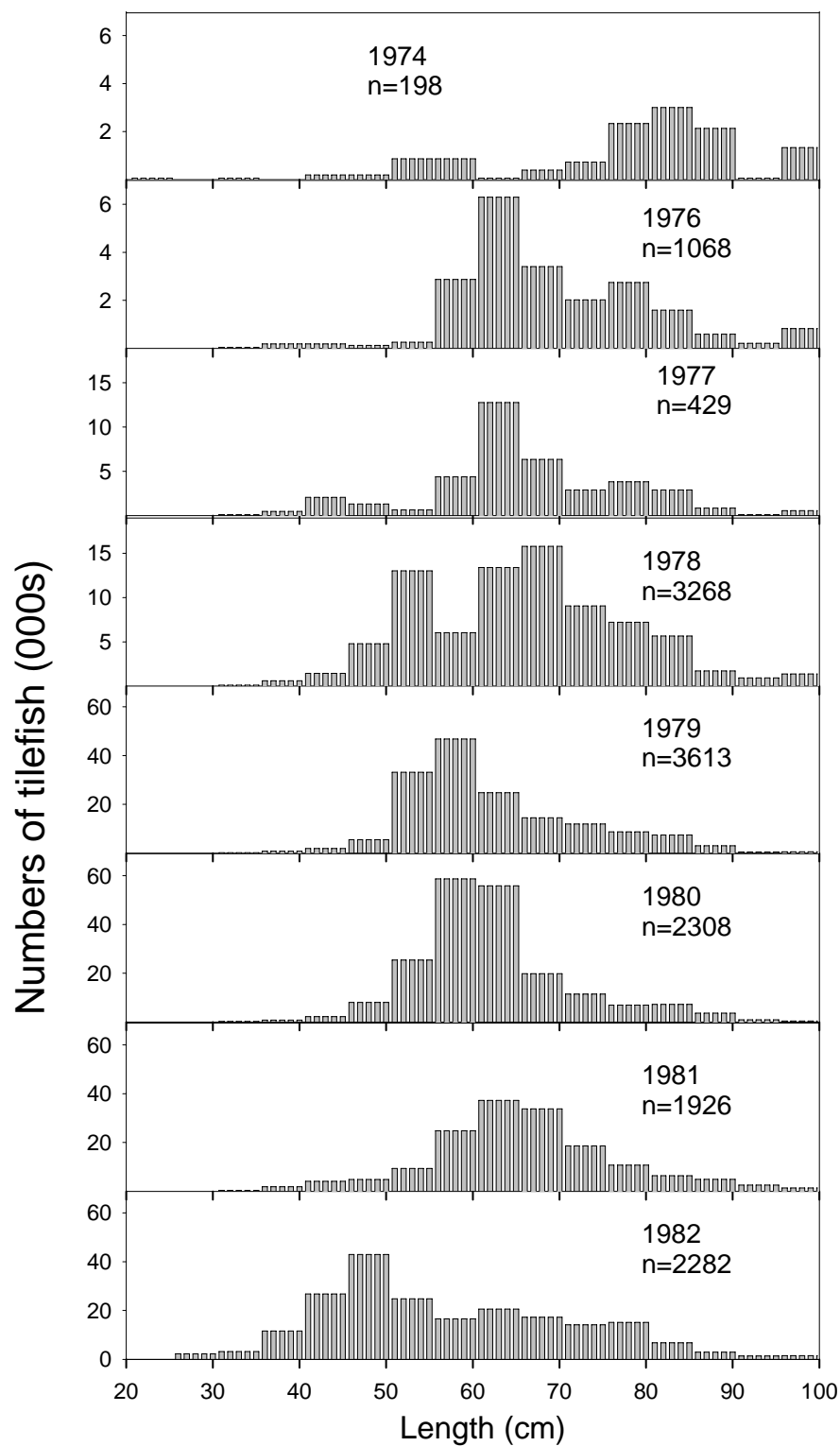
Figure C33. Expanded length frequency distributions using Turner (1986) length samples by 5 cm intervals. Hudson Canyon and Southern New England samples were combined.
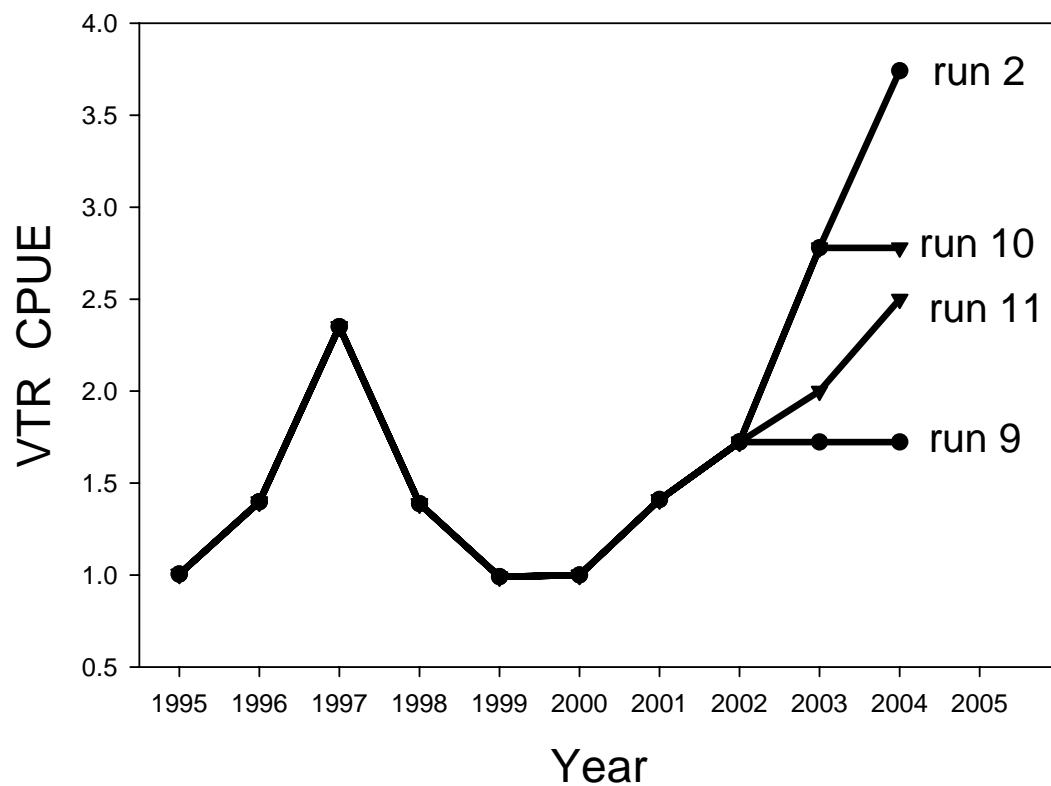
Figure C34. The actual VTR CPUE (run 2) and CPUE with lowered CPUE at the end of the time sereis used to determine sensitivity of the recent increase in CPUE in the ASPIC model.
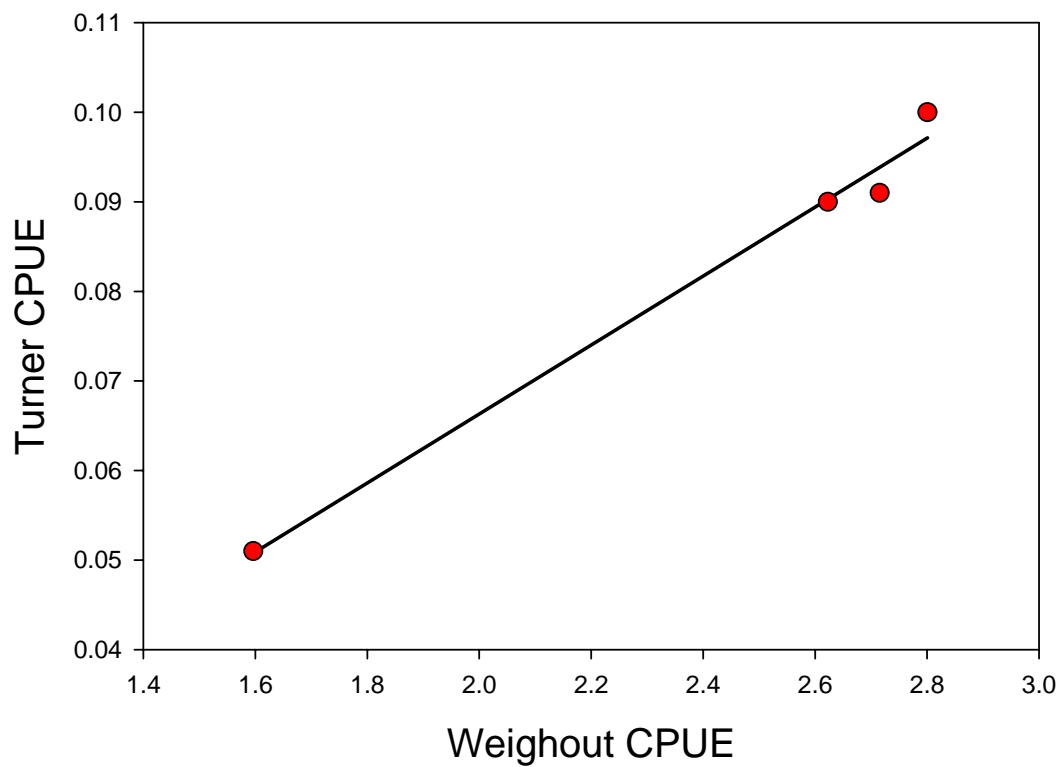
Figure C35. Regression (forced through zero) between the weighout CPUE and Turner CPUE using the four years of overlapping data (1979-1982). Regression was used to combine Turner and NEFSC series used in the AIM and LRSG model.
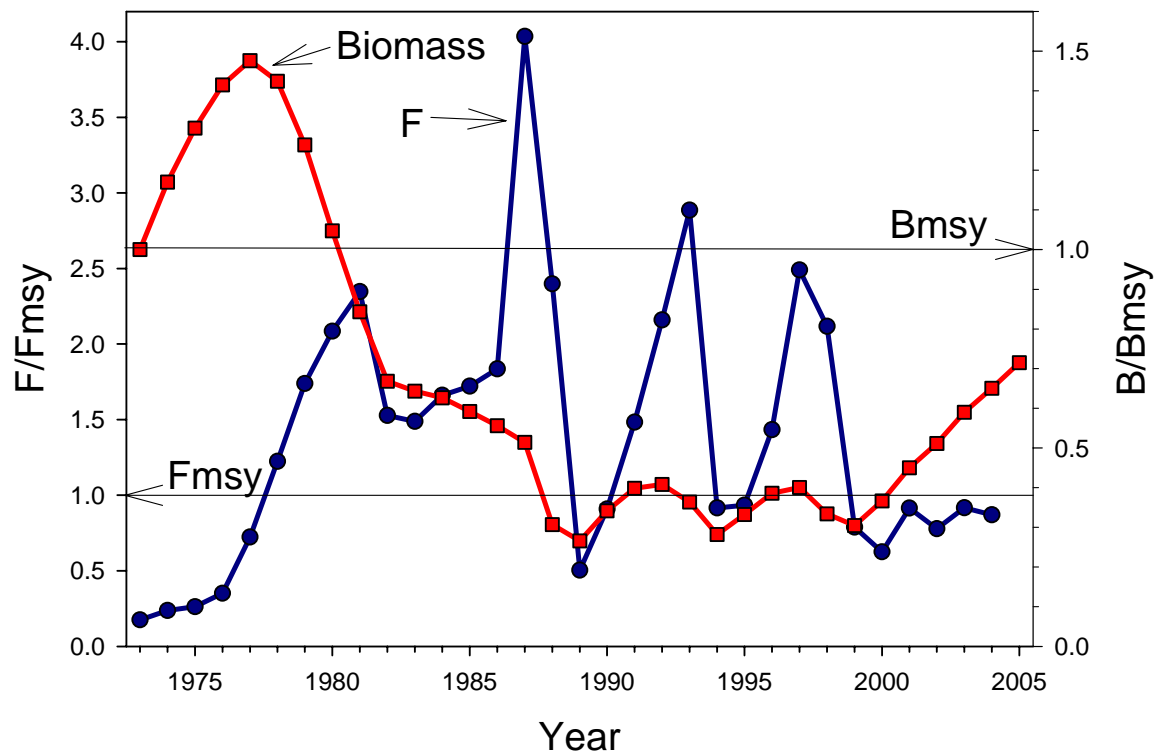
Figure C36. Trends in F/Fmsy and B/Bmsy ratios for the base ASPIC run 13 which fix the B1/Bmsy ratio at 1 and used three CPUE series (Turner, weighout, and VTR).
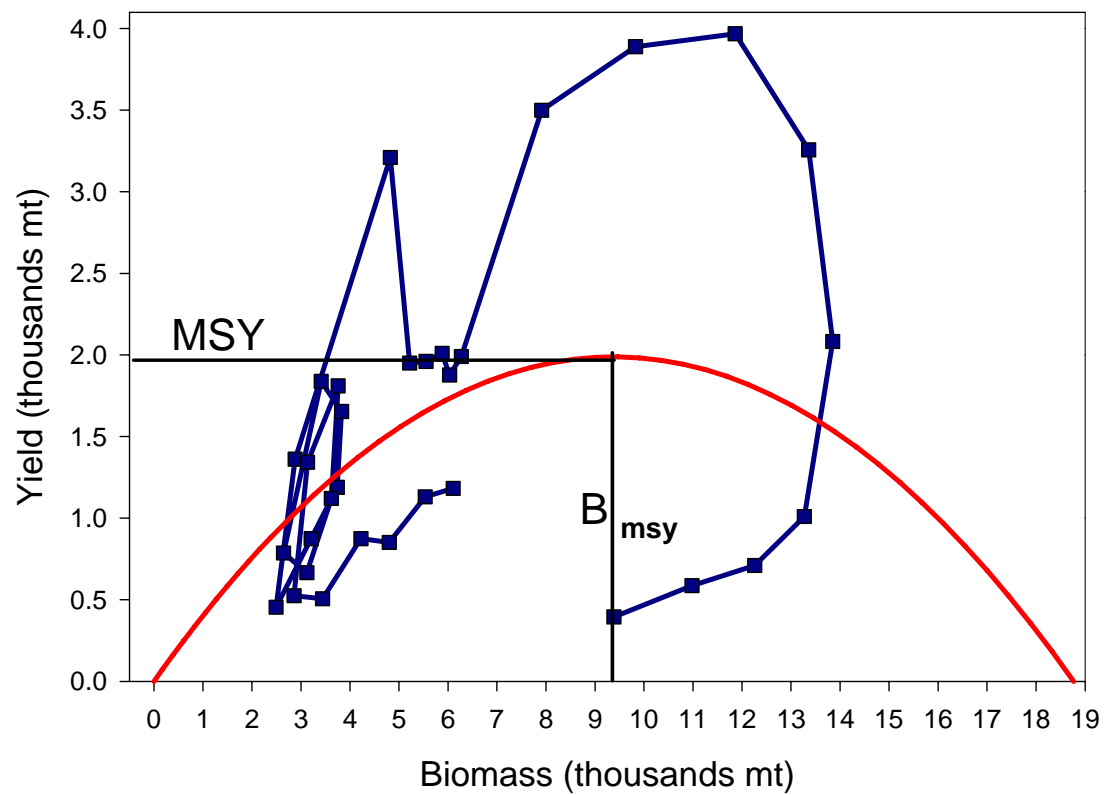
Figure C37. Observed and predicted equilibrium yield with biomass for the ASPIC model base run 13.
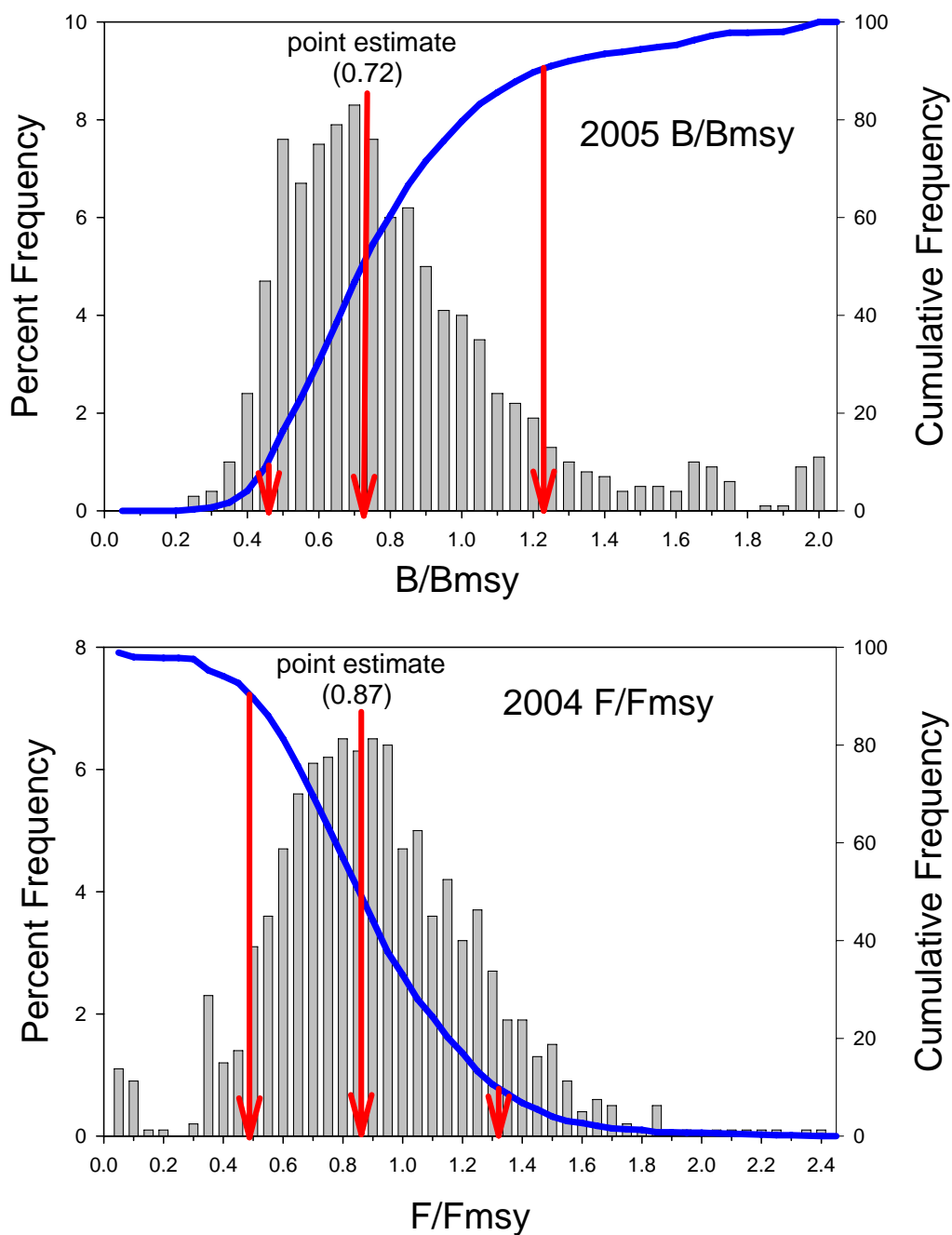
Figure C38. Precision of estimates of total stock biomass to B_{msy} ratios and fishing mortality to F_{msy} ratios for Golden tilefish. Vertical bars display the range of the boostrap estimates. The percent confidence limits can be taken of the cumulative frequency curve.
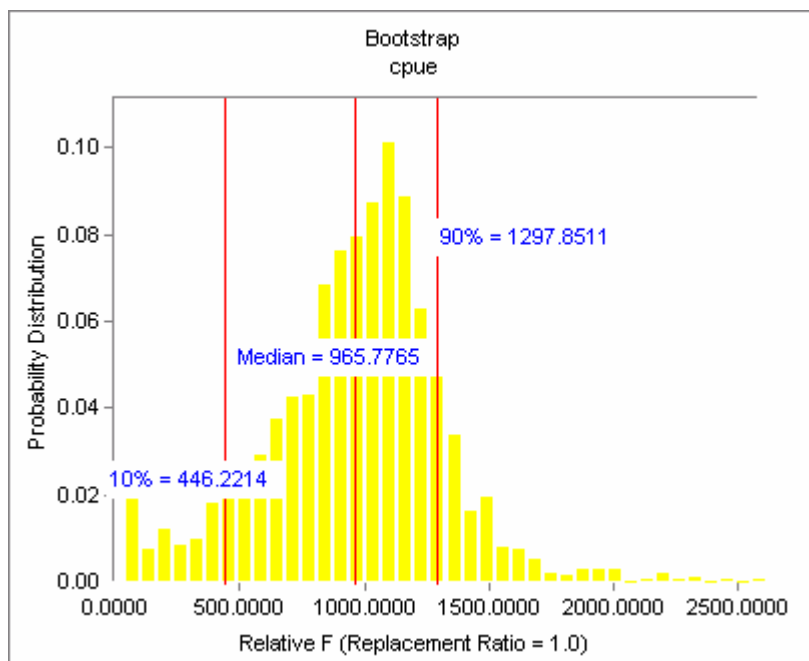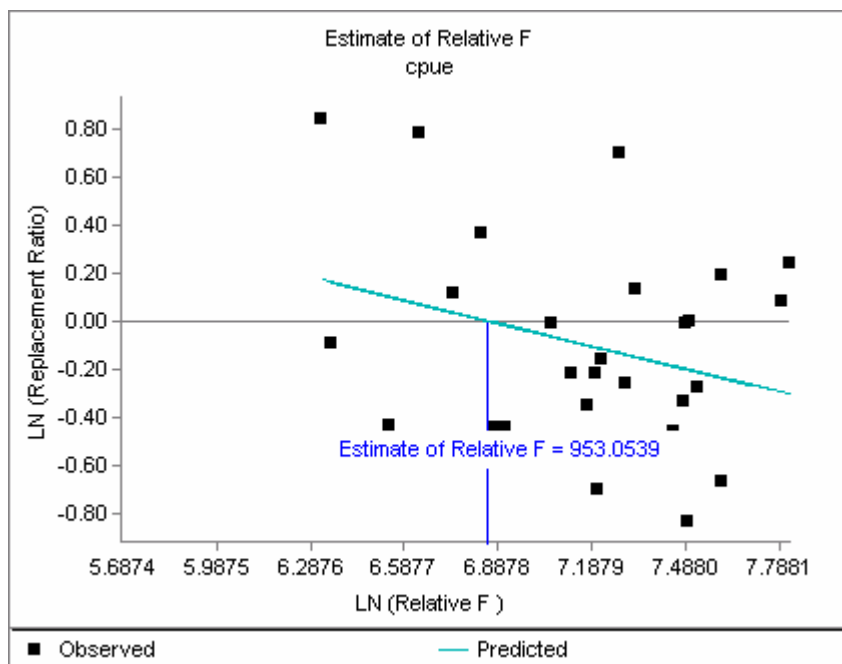
Figure C39. Aim model using combined Turner, NEFSC weighout and VTR CPUE (1973-2004). Top graph is the relationship between relative F and the replacement ratio. Bottom graph is the bootstrap distribution of relative Fs.
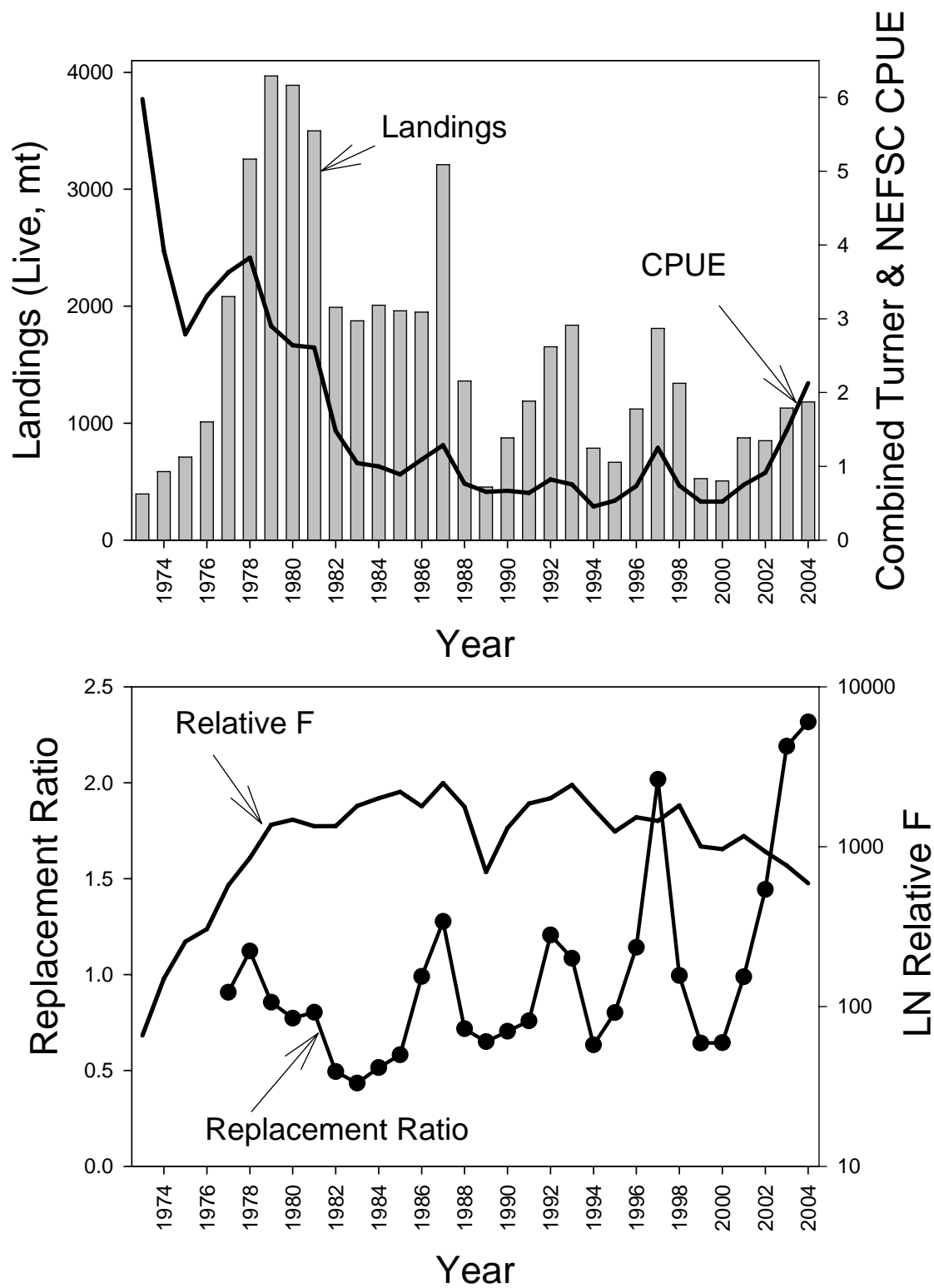
Figure C40. AIM model results using Turner and NEFSC commercial CPUE series combined.

Tilefish LSRG with steepness prior
CPUE time series fit
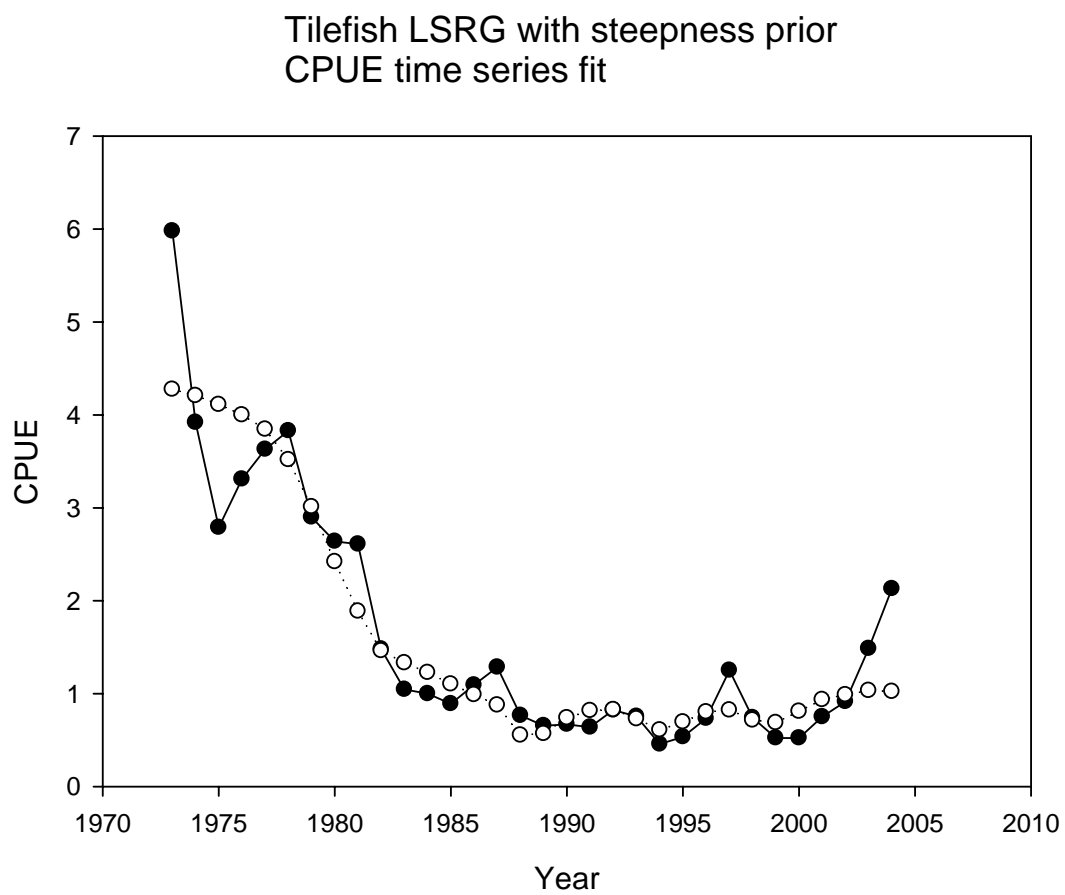
Figure C41. Observed and predicted CPUE from the LRSG model with a steepness prior.
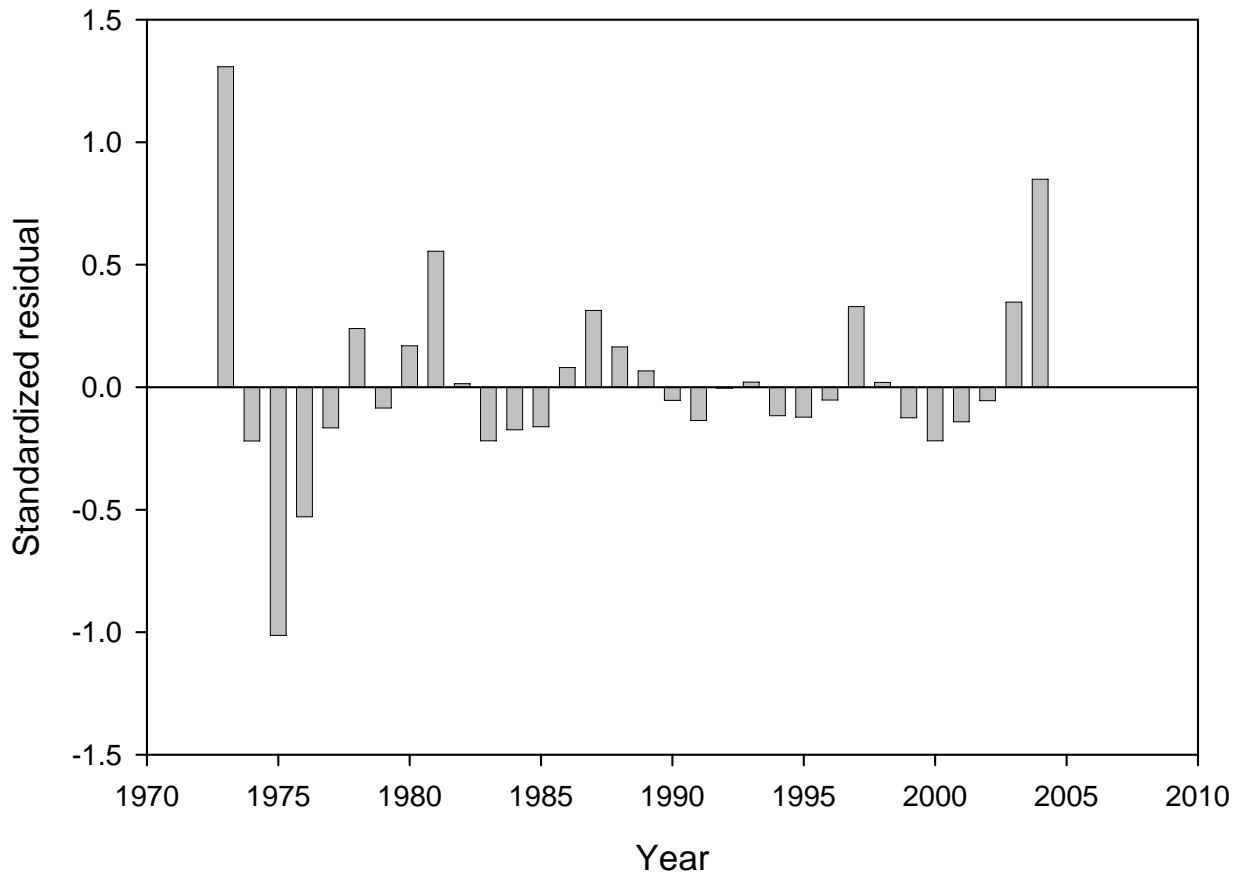
Figure C42. Standardized residuals form the LRSG model with a steepness prior.
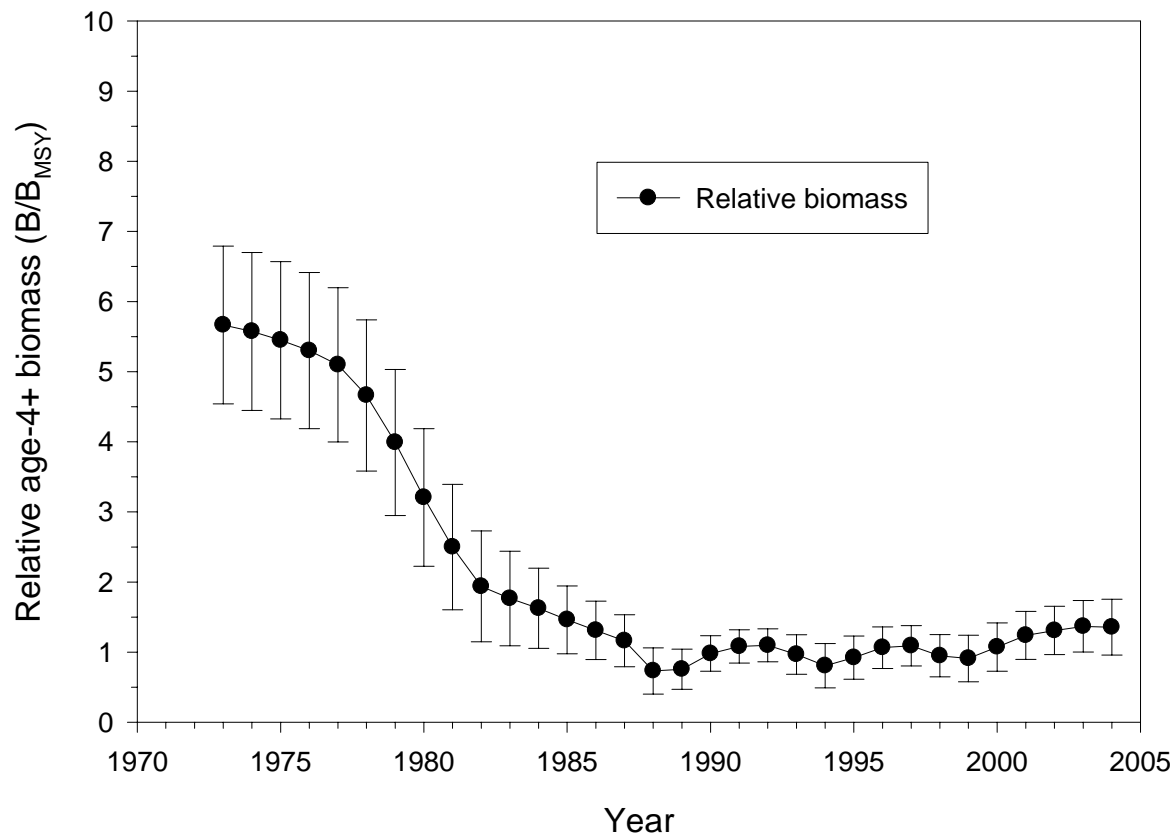
Figure C43. Relative biomass estimates from the LRSG model with a steepness prior.
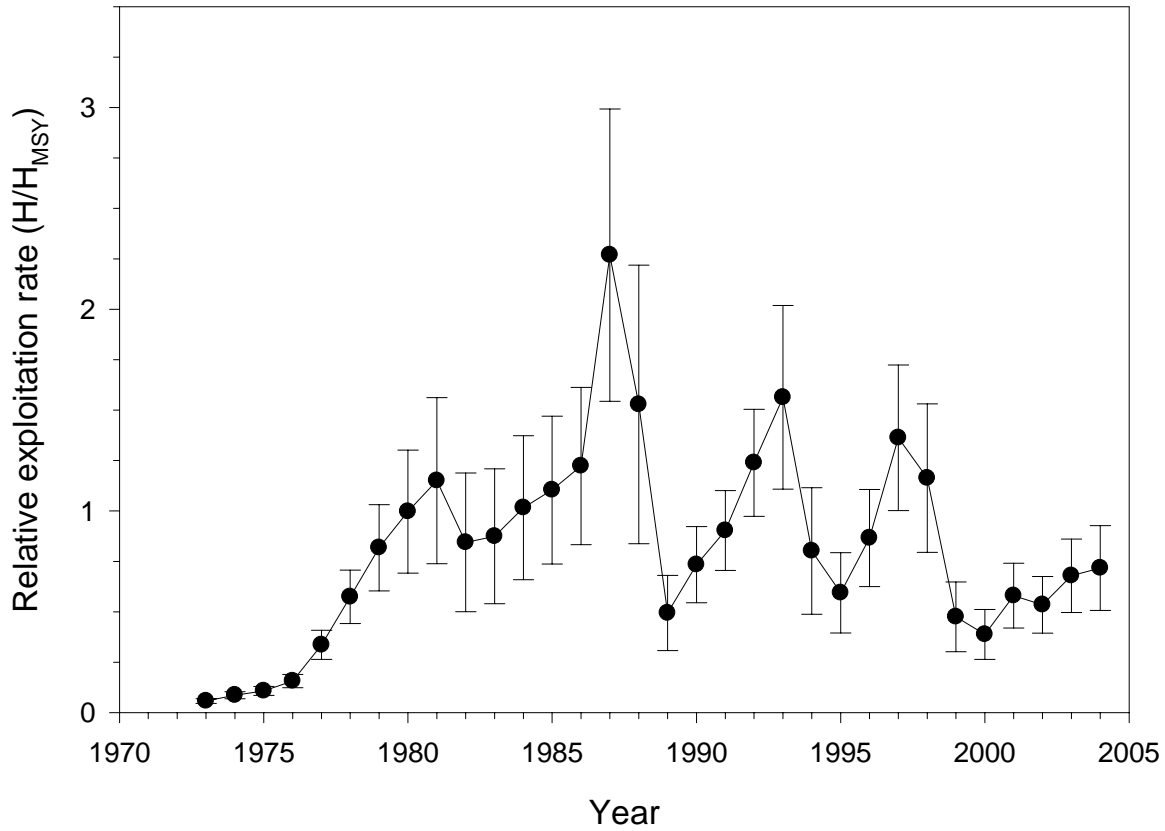
Figure C44. Relative harvest rate estimates from the LRSG model with a steepness prior.
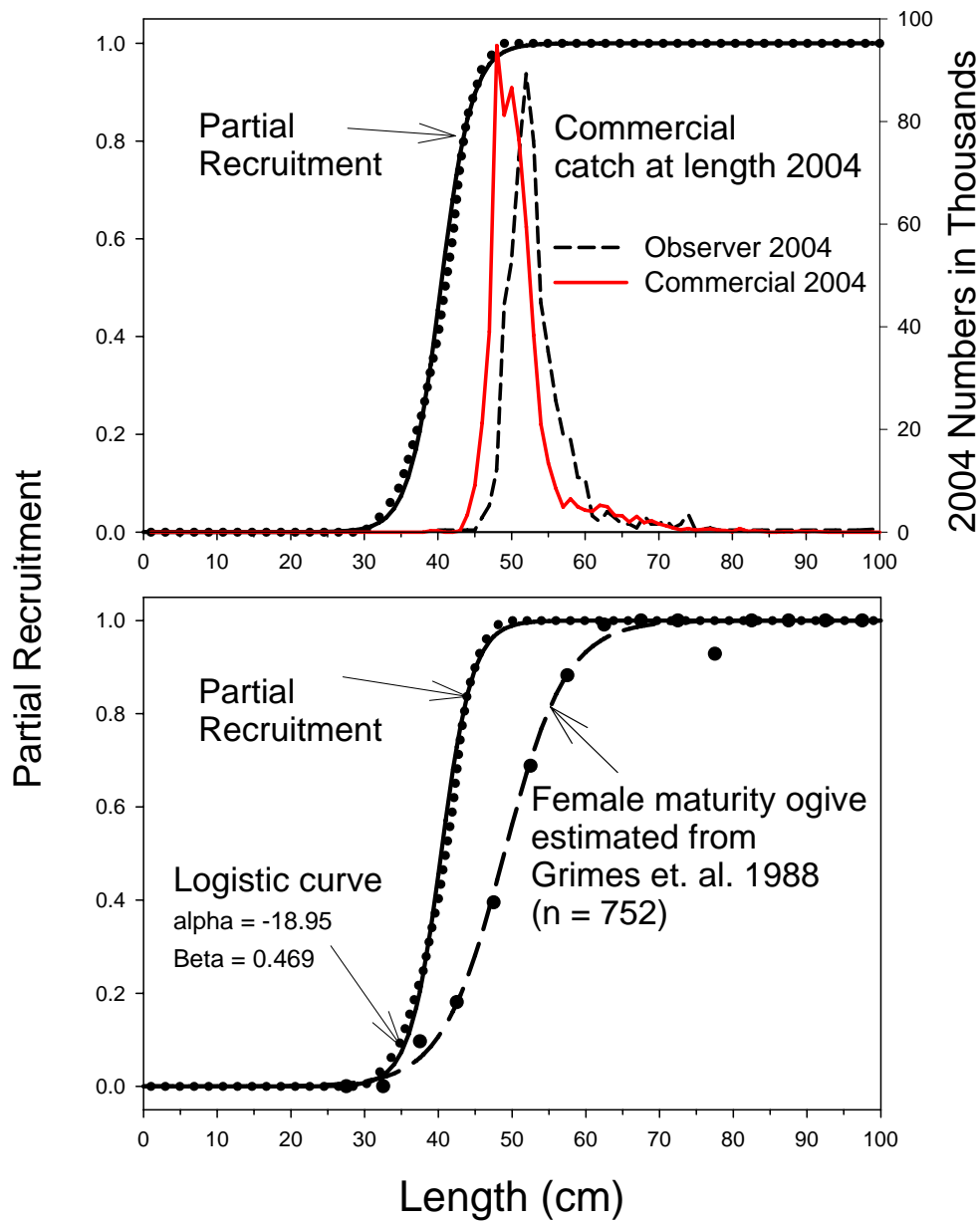
Figure C45. Top graph shows the partial recruitment and commercial/observer estimates of the expanded length frequency distributions for 2004. Bottom graph shows the maturity ogive from Grimes et. al. (1988) and the estimated logistic curve for the partial recruitment.
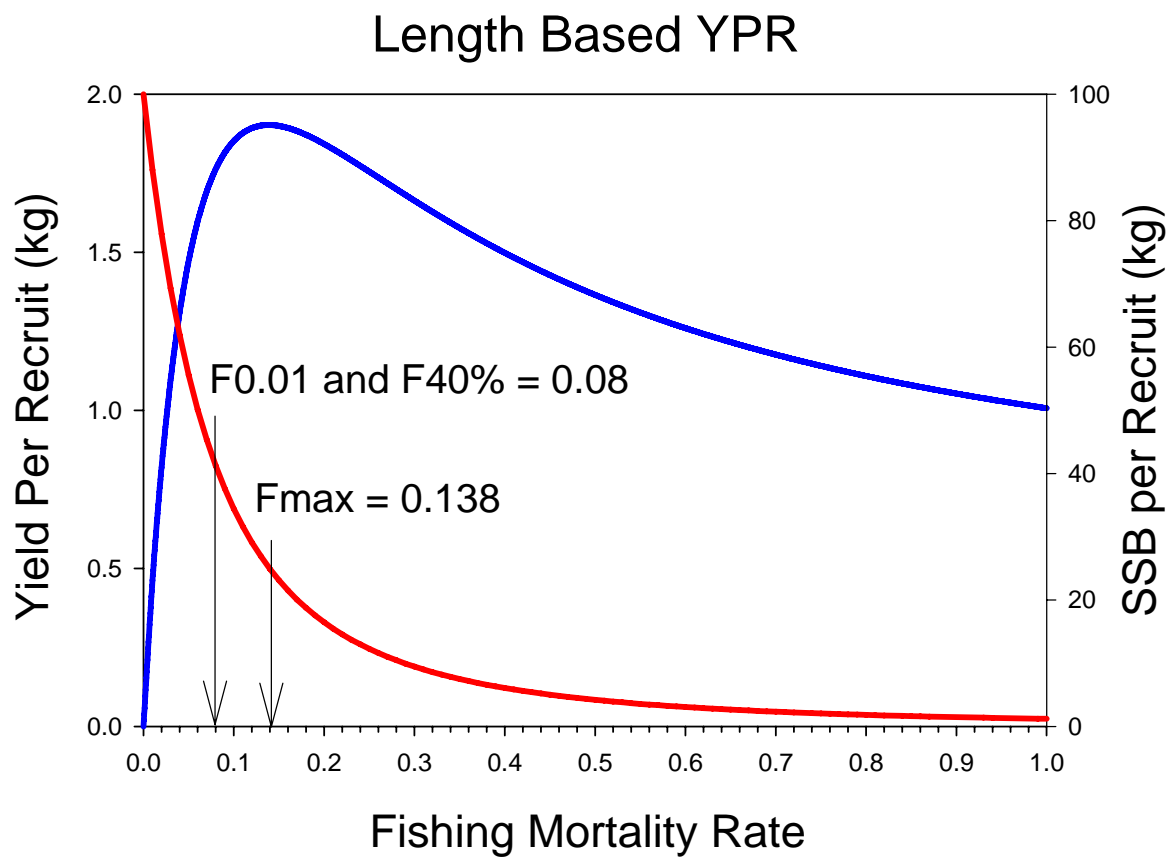
Figure C46. Yield per recruit (YPR) and spawning stock biomass per recruit (SSB/R) from the length based YPR analysis for Golden tilefish.

YPR from Catch-Length Model
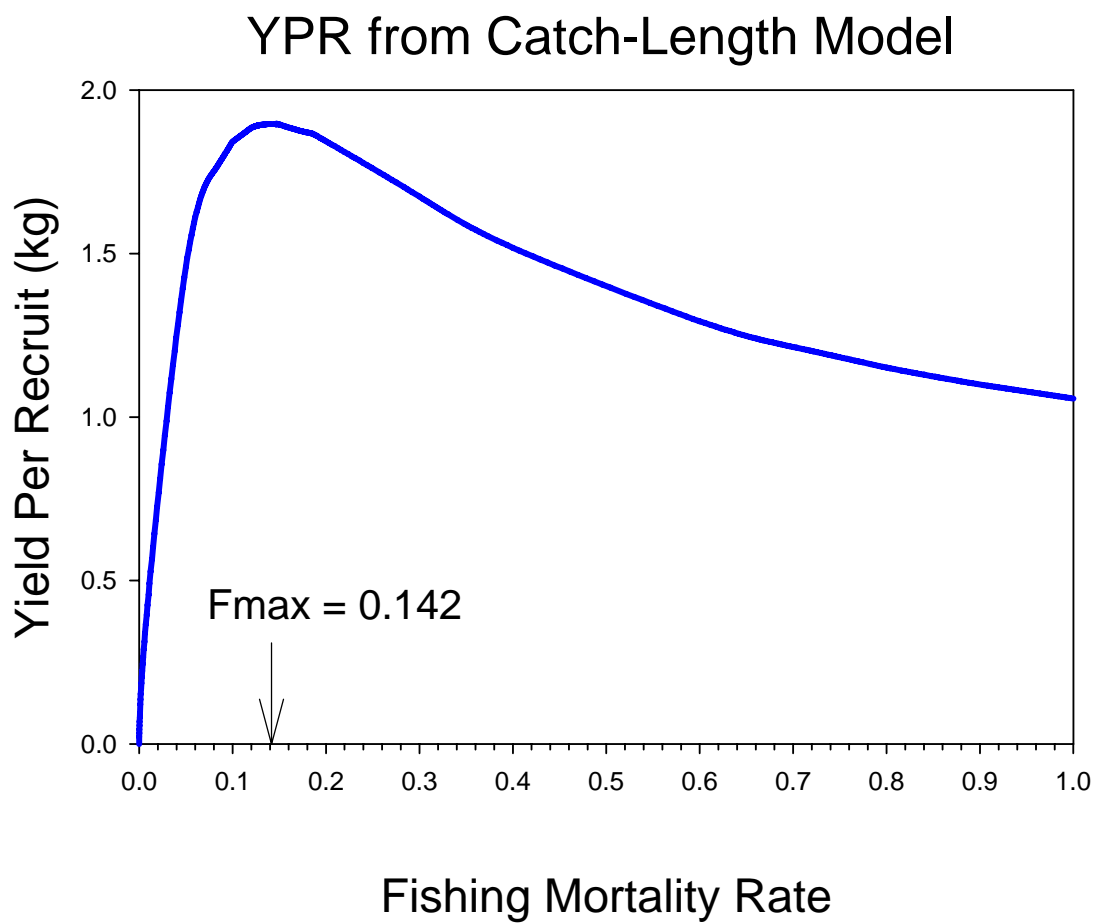
Figure C47. Yield per recruit (YPR) from the catch-length model for Golden tilefish.
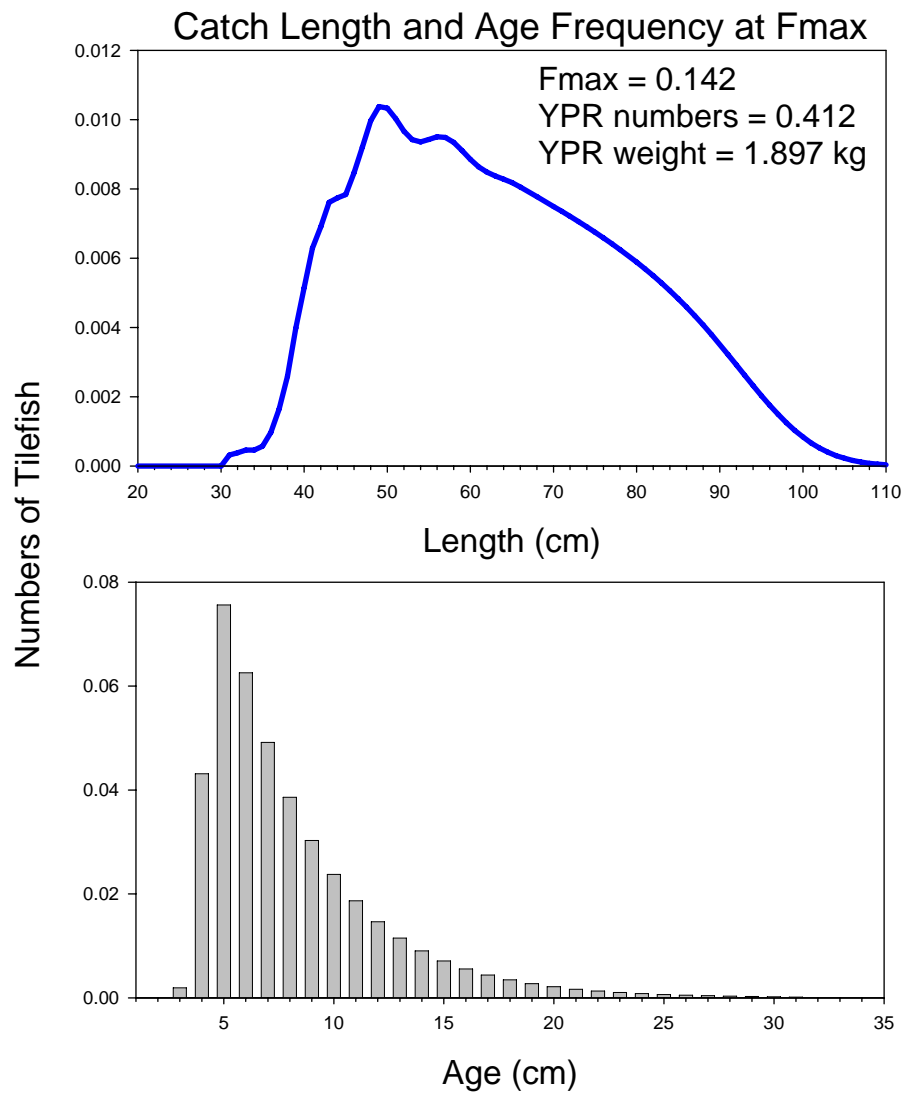
Figure C48. Predicted catch and age frequency at Fmax (0.142) using the catch-length model for Golden tilefish.

APPENDIX C1: Working Group Comments

The Working Group discussed the recreational data presented and questioned how 8800 trips could only catch 90 tilefish. It was noted that many tuna trips will fish for tilefish and may have listed tilefish as a secondary target. A request was made to limit the data to only trips that caught tilefish and trips that reported tilefish as a primary target. This reduced the number of trips to 2004. It was decided that the number of trips was not very meaningful given that tilefish catch in the recreational fishery appears to be a sporadic event. The recreational catch is currently not directly incorporated into the assessment but may become more of an issue as the stock recovers.

The Working Group discussed the CPUE series and decided to use the data as three separate series. The Turner series was estimated using different methodology than the later data. The weighout series and the VTR series were derived using the same methodology but the data in each part were collected in a different way. Looking at the vessels that have been in the fishery over time was very useful in the decision to keep the two series separate. Prior to 1994, vessels from New York were not in the weighout database individually. After 1994, they reported through the VTR system.

There were also concerns from the Working Group over changes in gear technology and fishing behavior over the time of the assessment. These changes may mask changes in abundance.

The Working Group reviewed several formulations of the ASPIC model. The group decided to use CPUE as three series and start the model in 1973. The formulations with the longer time series did not add anything to the more recent time frame. The group decided to fix the B1 ratio at 1 because the stock was not likely at carrying capacity in 1973 as the fishery had been occurring since 1916.

The Working Group reviewed two other models that gave slightly more optimistic views of the status of the stock, the AIM model and the LRSG model. Both models were promising for this stock but used a single CPUE series. The time trend of the LSRG model was similar to that of the ASPIC model run with a single CPUE series.

A Catch-at-length model was presented to the Working Group. The assumption of constant recruitment was discussed and may be a possible reason that the model does not fit the data very well and results in a spike of fishing mortality at the end of the time series. From the simulation work, an increase in fishing mortality can occur if you have both an increasing trend in fishing mortality and an increasing trend in recruitment. The length frequencies in the catch may or may not be an accurate reflection of the population length frequency, but may have more to do with fishing practices to maximize profit. The trawl length composition is not included in the model and may contribute to the lack of fit. Trawl catches of tilefish are generally smaller than those of longlines.

A length-based yield-per-recruit model was examined which confirmed a previous age-based YPR. The partial recruitment (PR) vector used may or may not reflect the fishery PR. If the fishery PR is dome-shaped then F_{max} may come closer to the F_{msy} of the ASPIC model. The PR

may also be changing from year to year based on market considerations. A bio-economic model that maximizes economic yield per recruit may be a useful tool.

The Working Group noted several signals coming out of the data. The current length frequency of the commercial catch is truncated relative to the 1970s length frequencies, but they were never as wide as expected from the maximum size of tilefish. The trawl catches are increasing, which may either be a sign of increased recruitment or increased allocation in recent years. The landings by vessels directing for tilefish have seen an increase in large animals indicating good stock size. Most of the models presented show some increase in biomass in recent years. Areas with increased amounts of offshore lobster gear may have created closed areas and refuges for the larger animals.

The Working Group discussed the uncertainty in the projections and whether to use the bias-corrected estimates or the ordinary estimates. It was decided to use the ordinary estimates for two sets of projections. The first would be a status quo catch of 905 mt and the second would be 905 mt for 2005 and then a constant catch that would allow the stock to recover to B_{msy} by 2011. Discussion also occurred as to the unusual erratic behavior of this particular projection. It may be that the large increase in CPUE in the last two years is causing the model to have more uncertainty causing a large estimate of bias. It was suggested to try starting the model projections at 2002. The Working Group considered these projections to be too uncertain to form the basis of TAC advice.

Research Recommendations

Research Recommendations from 1998 Science and Statistical Committee review

1) Ensure that market category distributions accurately reflect the landings.
2) Ensure that length frequency sampling is proportional to landings by market category.
3) Increase and ensure adequate length sampling coverage of the fishery
4) Update age- and length-weight relationships.
5) Update the maturity-at-age, weight-at-age, and partial recruitment patterns.
6) Develop fork length to total length conversion factors for the estimation of total length to weight relationships
7) Incorporate auxiliary data to estimate r independent of the ASPIC model.

The Working Group noted that sampling has improved for 2003 and 2004. This addresses 1, 2, and 3. A hook selectivity study is planned for 2005-2006 and data will be collected to address 4 and 5. Work is in progress collecting total length and fork length data to address 6. Nothing has been done to date to address 7.

APPENDIX C2: NEFSC Weighout CPUE GLM model

```
The SAS System
14:00 Thursday, March 31, 2005    1
The GLM Procedure
                                        Class Level Information
Class      Levels  Values

lndyear        15  1979 1980 1981 1982 1983 1985 1986 1987 1988 1989 1990 1991 1992 1993 9999

permit         92      delete permit numbers
Number of observations   1897
The SAS System
14:00 Thursday, March 31, 2005    2

The GLM Procedure
 Dependent Variable: LNCPUE


                                 Sum of
Source                   DF      Squares    Mean Square   F Value   Pr > F
Model                   105   743.569869      7.081618     23.67   <.0001
Error                  1791   535.787323      0.299155

Corrected Total        1896  1279.357192

R-Square    Coeff Var    Root MSE    LNCPUE Mean
0.581206     8.116663    0.546951       6.738619

Source                   DF     Type I SS    Mean Square   F Value   Pr > F
lndyear                  14   566.9637531     40.4974109    135.37   <.0001
permit                   91   176.6061156      1.9407265      6.49   <.0001

Source                   DF   Type III SS    Mean Square   F Value   Pr > F
lndyear                  14   281.1521083     20.0822934     67.13   <.0001
permit                   91   176.6061156      1.9407265      6.49   <.0001

                                Standard
Parameter            Estimate      Error    t Value    Pr > |t|

Intercept         6.232567267 B  0.11429828    54.53    <.0001
lndyear  1979     1.022878443 B  0.07430951    13.77    <.0001
lndyear  1980     0.991305758 B  0.07181247    13.80    <.0001
lndyear  1981     0.957632235 B  0.07168379    13.36    <.0001
lndyear  1982     0.461931590 B  0.07359297     6.28    <.0001
lndyear  1983     0.036989477 B  0.07511938     0.49    0.6225
lndyear  1985    -0.116577906 B  0.07301030    -1.60    0.1105
lndyear  1986     0.078237855 B  0.07992860     0.98    0.3278
lndyear  1987     0.235247667 B  0.07689409     3.06    0.0023
lndyear  1988    -0.290869711 B  0.08580020    -3.39    0.0007
lndyear  1989    -0.437414680 B  0.11355219    -3.85    0.0001
lndyear  1990    -0.412418009 B  0.10524248    -3.92    <.0001
lndyear  1991    -0.462210977 B  0.09637704    -4.80    <.0001
lndyear  1992    -0.213720208 B  0.09349023    -2.29    0.0224
lndyear  1993    -0.277906028 B  0.09113548    -3.05    0.0023
lndyear  9999     0.000000000 B      .            .         .
permit   -        0.053877941 B  0.39953947     0.13    0.8927
permit   -        0.290799259 B  0.40217631     0.72    0.4697
permit   -        2.200653904 B  0.55660933     3.95    <.0001
permit   -       -0.720065816 B  0.33062733    -2.18    0.0295
permit   -        1.204048080 B  0.23673422     5.09    <.0001
permit   -       -0.918838210 B  0.55660933    -1.65    0.0990
permit   -        0.884977111 B  0.55660933     1.59    0.1120
permit   -        0.089186369 B  0.13030426     0.68    0.4938
permit   -        0.351073875 B  0.55660933     0.63    0.5283
permit   -       -0.474685588 B  0.40127024    -1.18    0.2370
permit   -       -1.051239079 B  0.55796370    -1.88    0.0597
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permit   -        0.042036558 B  0.15197217     0.28    0.7821
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permit      -      -2.501448583 B      0.55827964     -4.48     <.0001
permit      -       0.450272193 B      0.12822212      3.51     0.0005
permit      -       0.471191134 B      0.55809344      0.84     0.3986
permit      -      -0.050060896 B      0.14723604     -0.34     0.7339
permit      -      -0.138317903 B      0.24734699     -0.56     0.5761
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permit      -      -0.719753788 B      0.55856606     -1.29     0.1977
permit      -       0.539895149 B      0.20257954      2.67     0.0078
permit      -       0.200325406 B      0.14810284      1.35     0.1764
permit      -       0.166798650 B      0.13012707      1.28     0.2001
permit      -       0.171959971 B      0.11302093      1.52     0.1283
permit      -       0.231976547 B      0.12244851      1.89     0.0583
permit      -       0.024125664 B      0.13432034      0.18     0.8575
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permit      -       0.202892095 B      0.11692497      1.74     0.0829
permit      -      -0.150565146 B      0.55660933     -0.27     0.7868
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permit      -       0.055682092 B      0.55606608      0.10     0.9202
permit      -       0.476788308 B      0.56089822      0.85     0.3954
permit      -      -1.513147475 B      0.22407363     -6.75     <.0001
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permit      -      -0.260880622 B      0.40623775     -0.64     0.5208
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permit      -       0.565119319 B      0.29382393      1.92     0.0546
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permit      -      -0.144900138 B      0.55876605     -0.26     0.7954
permit      -      -0.018365360 B      0.39831869     -0.05     0.9632
permit      -       0.233109656 B      0.24325318      0.96     0.3380
permit      -       0.579583698 B      0.55656992      1.04     0.2979
permit      -       0.280357477 B      0.14815327      1.89     0.0586
permit      -      -0.220190021 B      0.33549831     -0.66     0.5117
permit      -       0.477244382 B      0.17126647      2.79     0.0054
permit      -       0.586558492 B      0.29544304      1.99     0.0473
permit      -       1.003951166 B      0.55606608      1.81     0.0712
permit      -       0.882877530 B      0.33498687      2.64     0.0085
permit      -       0.191509700 B      0.24286878      0.79     0.4305
permit      -       0.297364159 B      0.29099874      1.02     0.3070
permit      -       0.283495433 B      0.12957609      2.19     0.0288
permit      -       1.042813481 B      0.56089822      1.86     0.0632
permit      -      -0.065468315 B      0.19188028     -0.34     0.7330
permit      -      -0.153684912 B      0.40328873     -0.38     0.7032
permit      -       0.036432483 B      0.15621610      0.23     0.8156
permit      -       0.099929826 B      0.29223882      0.34     0.7324
```

```
permit      -        0.224377910 B      0.11753056       1.91       0.0564
permit      -        0.334472400 B      0.29263852       1.14       0.2532
permit      -        0.346528767 B      0.39933585       0.87       0.3856
permit      -        0.131354900 B      0.17613902       0.75       0.4559
permit      -        0.056859718 B      0.15272950       0.37       0.7097
permit      -       -1.420176111 B      0.55660933      -2.55       0.0108
permit      -       -1.054505031 B      0.33062733      -3.19       0.0015
permit      -        1.290671749 B      0.56253472       2.29       0.0219
permit      -       -0.545675103 B      0.55660933      -0.98       0.3270
permit      -        0.722755358 B      0.12789264       5.65      <.0001
permit      -        0.000000000 B          .             .          .
```

APPENDIX C3: NEFSC VTR CPUE GLM model

```
The SAS System
14:00 Thursday, March 31, 2005    6

The GLM Procedure
                                          Class Level Information
Class       Levels  Values

lndyear        10   1995 1996 1997 1998 1999 2001 2002 2003 2004 9999

permit         25 delete permit numbers

Number of observations    1226
The SAS System
14:00 Thursday, March 31, 2005    7

The GLM Procedure

Dependent Variable: LNCPUE

                                   Sum of
Source                      DF      Squares     Mean Square    F Value    Pr > F
Model                       33   331.2333689    10.0373748      54.83     <.0001
Error                     1192   218.2168857     0.1830679
Corrected Total           1225   549.4502547

R-Square     Coeff Var     Root MSE     LNCPUE Mean
0.602845     6.542155     0.427864       6.540113

Source                      DF      Type I SS    Mean Square    F Value    Pr > F
lndyear                      9   228.8146560    25.4238507     138.88     <.0001
permit                      24   102.4187130     4.2674464      23.31     <.0001

Source                      DF    Type III SS    Mean Square    F Value    Pr > F
lndyear                      9   174.3859974    19.3762219     105.84     <.0001
permit                      24   102.4187130     4.2674464      23.31     <.0001

                                  Standard
Parameter            Estimate         Error     t Value    Pr > |t|

Intercept          5.113658653 B    0.25524735     20.03     <.0001
lndyear    1995    0.003251958 B    0.06064188      0.05     0.9572
lndyear    1996    0.333649416 B    0.05686636      5.87     <.0001
lndyear    1997    0.852841891 B    0.05578225     15.29     <.0001
lndyear    1998    0.326173101 B    0.05434864      6.00     <.0001
lndyear    1999   -0.010167260 B    0.05602196     -0.18     0.8560
lndyear    2001    0.341776436 B    0.05753438      5.94     <.0001
lndyear    2002    0.542159089 B    0.05809594      9.33     <.0001
lndyear    2003    1.020162126 B    0.06030139     16.92     <.0001
lndyear    2004    1.317256060 B    0.06425412     20.50     <.0001
lndyear    9999    0.000000000 B       .             .         .
permit     -       0.961909899 B    0.49808246      1.93     0.0537
permit     -      -1.056374914 B    0.31554991     -3.35     0.0008
permit     -      -1.126161751 B    0.39058488     -2.88     0.0040
permit     -      -0.219682088 B    0.39583474     -0.55     0.5790
permit     -       1.031794240 B    0.49773781      2.07     0.0384
permit     -      -0.105358649 B    0.31694803     -0.33     0.7396
permit     -       0.196988940 B    0.27462680      0.72     0.4733
permit     -       0.783944131 B    0.30800139      2.55     0.0110
permit     -       1.417322553 B    0.30254575      4.68     <.0001
permit     -       0.066578059 B    0.26406366      0.25     0.8010
permit     -       0.872233511 B    0.25449976      3.43     0.0006
permit     -       1.470460556 B    0.31246790      4.71     <.0001
permit     -       0.858064274 B    0.26325314      3.26     0.0011
permit     -       0.482304252 B    0.29211263      1.65     0.0990
```

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```
permit     -        1.011645989 B     0.28165476       3.59      0.0003
permit     -        1.914340963 B     0.49796734       3.84      0.0001
permit     -        0.933575330 B     0.25354360       3.68      0.0002
permit     -       -1.099661139 B     0.49821588      -2.21      0.0275
permit     -        0.944271665 B     0.25359215       3.72      0.0002
permit     -        1.163582345 B     0.35355219       3.29      0.0010
permit     -        1.140939563 B     0.25261419       4.52      <.0001
permit     -       -1.595414622 B     0.49850958      -3.20      0.0014
permit     -        0.891670841 B     0.28966550       3.08      0.0021
permit     -        1.075896536 B     0.25270683       4.26      <.0001
permit     -        0.000000000 B     .                .         .
```

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve
the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely
estimable.

APPENDIX C4: ASPIC Run 13 with Bootstrap

```
TILEFISH -- three series                                          Page 1
                                                         04 May 2005 at 08:31.18
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.93)    BOT Mode
Author: Michael H. Prager; NOAA/NMFS/S.E. Fisheries Science Center   ASPIC User's Manual
        101 Pivers Island Road; Beaufort, North Carolina  28516  USA    is available gratis
                                                                         from the author.
Ref:    Prager, M. H.  1994.  A suite of extensions to a nonequilibrium
        surplus-production model.  Fishery Bulletin 92: 374-389.


CONTROL PARAMETERS USED (FROM INPUT FILE)
--------------------------------------------------------------------------------------------
Number of years analyzed:                    32    Number of bootstrap trials:        1000
Number of data series:                        3    Lower bound on MSY:            1.000E-01
Objective function computed:            in effort   Upper bound on MSY:            9.000E+01
Relative conv. criterion (simplex):     1.000E-08   Lower bound on r:              1.000E-01
Relative conv. criterion (restart):     3.000E-08   Upper bound on r:              1.000E+02

Relative conv. criterion (effort):      1.000E-04   Random number seed:            973142085
Maximum F allowed in fitting:               5.000   Monte Carlo search mode, trials: 1  50000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                        code  0
--------------------------------------------------------------------------------------------
Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
--------------------------------------------------------------------------------------------
                                 |
  1  weighout cpue               |   1.000
                                 |     15
                                 |
  2  turner                      |   0.994   1.000
                                 |     4       10
                                 |
  3  vtr                         |   0.000   0.000   1.000
                                 |     0       0       10
                                 -------------------------------------------------
                                     1       2       3


GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS
--------------------------------------------------------------------------------------------
                                Weighted           Weighted   Current   Suggested   R-squared
Loss component number and title    SSE      N        MSE       weight     weight     in CPUE

Loss(-1)  SSE in yield          0.000E+00
Loss( 0)  Penalty for B1R > 2   0.000E+00    1       N/A     0.000E+00     N/A
Loss( 1)  weighout cpue         1.254E+00   15    9.647E-02  1.000E+00   9.982E-01    0.703
Loss( 2)  turner                6.714E-01   10    8.393E-02  1.000E+00   1.147E+00    0.180
Loss( 3)  vtr                   9.007E-01   10    1.126E-01  1.000E+00   8.553E-01    0.538
TOTAL OBJECTIVE FUNCTION:       2.82613812E+00

Number of restarts required for convergence:            18
Est. B/Bmsy coverage index (0 worst, 2 best):       1.2109 <These two measures are defined in Prager
Est. B/Bmsy nearness index (0 worst, 1 best):       1.0000 < et al. (1996), Trans. A.F.S. 125:729

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
--------------------------------------------------------------------------------------------
Parameter                                   Estimate    Starting guess   Estimated   User guess

B1R      Starting B/Bmsy, year 1973        1.000E+00      1.000E+00          0           1
MSY      Maximum sustainable yield         1.988E+00      3.000E+00          1           1
r        Intrinsic rate of increase        4.237E-01      3.000E-01          1           1
........  Catchability coefficients by fishery:
q( 1)    weighout cpue                     2.245E-01      3.000E-02          1           1
```

```
q( 2)    turner                                    1.033E-02    3.000E-02      1        1
q( 3)    vtr                                       3.921E-01    3.000E-02      1        1


MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
-----------------------------------------------------------------------------------------------
Parameter                                         Estimate         Formula       Related
quantity

MSY       Maximum sustainable yield               1.988E+00          Kr/4
K         Maximum stock biomass                   1.877E+01
Bmsy      Stock biomass at MSY                    9.384E+00          K/2
Fmsy      Fishing mortality at MSY                2.118E-01          r/2

F(0.1)    Management benchmark                    1.906E-01         0.9*Fmsy
Y(0.1)    Equilibrium yield at F(0.1)             1.968E+00         0.99*MSY

B./Bmsy   Ratio of B(2005) to Bmsy                7.153E-01
F./Fmsy   Ratio of F(2004) to Fmsy                8.703E-01
F01-mult  Ratio of F(0.1) to F(2004)              1.034E+00
Ye./MSY   Proportion of MSY avail in 2005         9.189E-01       2*Br-Br^2   Ye(2005) = 1.827E+00

........  Fishing effort at MSY in units of each fishery:
fmsy( 1)  weighout cpue                           9.434E-01        r/2q( 1)    f(0.1) = 8.491E-01

TILEFISH -- three series                                                          Page 2

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)
-----------------------------------------------------------------------------------------------
        Estimated   Estimated   Estimated   Observed   Model     Estimated    Ratio of    Ratio of
  Year   total       starting    average     total      total     surplus      F mort      biomass
Obs or ID F mort     biomass     biomass     yield      yield     production   to Fmsy     to Bmsy

  1  1973   0.037   9.384E+00   1.064E+01   3.940E-01  3.940E-01  1.985E+00   1.748E-01   1.000E+00
  2  1974   0.050   1.098E+01   1.163E+01   5.860E-01  5.860E-01  1.870E+00   2.378E-01   1.170E+00
  3  1975   0.056   1.226E+01   1.278E+01   7.100E-01  7.100E-01  1.725E+00   2.622E-01   1.306E+00
  4  1976   0.074   1.327E+01   1.358E+01   1.010E+00  1.010E+00  1.590E+00   3.512E-01   1.415E+00
  5  1977   0.153   1.385E+01   1.359E+01   2.082E+00  2.082E+00  1.587E+00   7.231E-01   1.476E+00
  6  1978   0.259   1.336E+01   1.256E+01   3.257E+00  3.257E+00  1.756E+00   1.224E+00   1.424E+00
  7  1979   0.368   1.186E+01   1.077E+01   3.968E+00  3.968E+00  1.937E+00   1.739E+00   1.264E+00
  8  1980   0.442   9.828E+00   8.804E+00   3.889E+00  3.889E+00  1.973E+00   2.085E+00   1.047E+00
  9  1981   0.497   7.912E+00   7.039E+00   3.499E+00  3.499E+00  1.859E+00   2.347E+00   8.432E-01
 10  1982   0.324   6.272E+00   6.149E+00   1.990E+00  1.990E+00  1.752E+00   1.528E+00   6.684E-01
 11  1983   0.315   6.034E+00   5.954E+00   1.877E+00  1.877E+00  1.722E+00   1.488E+00   6.430E-01
 12  1984   0.352   5.879E+00   5.711E+00   2.009E+00  2.009E+00  1.683E+00   1.661E+00   6.265E-01
 13  1985   0.364   5.553E+00   5.380E+00   1.961E+00  1.961E+00  1.626E+00   1.721E+00   5.917E-01
 14  1986   0.389   5.218E+00   5.015E+00   1.950E+00  1.950E+00  1.557E+00   1.836E+00   5.560E-01
 15  1987   0.855   4.824E+00   3.755E+00   3.210E+00  3.210E+00  1.266E+00   4.035E+00   5.141E-01
 16  1988   0.508   2.880E+00   2.679E+00   1.361E+00  1.361E+00  9.728E-01   2.398E+00   3.069E-01
 17  1989   0.107   2.492E+00   4.249E+00   4.540E-01  4.540E-01  1.171E+00   5.044E-01   2.655E-01
 18  1990   0.192   3.208E+00   4.544E+00   8.740E-01  8.740E-01  1.404E+00   9.081E-01   3.419E-01
 19  1991   0.314   3.739E+00   3.785E+00   1.189E+00  1.189E+00  1.280E+00   1.483E+00   3.984E-01
 20  1992   0.457   3.830E+00   3.615E+00   1.653E+00  1.653E+00  1.236E+00   2.159E+00   4.081E-01
 21  1993   0.611   3.413E+00   3.008E+00   1.838E+00  1.838E+00  1.069E+00   2.885E+00   3.637E-01
 22  1994   0.194   2.644E+00   4.055E+00   7.860E-01  7.860E-01  1.260E+00   9.151E-01   2.817E-01
 23  1995   0.198   3.118E+00   3.367E+00   6.660E-01  6.660E-01  1.170E+00   9.338E-01   3.322E-01
 24  1996   0.304   3.622E+00   3.690E+00   1.121E+00  1.121E+00  1.256E+00   1.434E+00   3.860E-01
 25  1997   0.527   3.757E+00   3.432E+00   1.810E+00  1.810E+00  1.187E+00   2.490E+00   4.003E-01
 26  1998   0.448   3.134E+00   2.992E+00   1.342E+00  1.342E+00  1.065E+00   2.117E+00   3.340E-01
 27  1999   0.167   2.858E+00   3.144E+00   5.250E-01  5.250E-01  1.108E+00   7.884E-01   3.045E-01
 28  2000   0.132   3.441E+00   3.825E+00   5.060E-01  5.060E-01  1.289E+00   6.246E-01   3.667E-01
 29  2001   0.194   4.224E+00   4.511E+00   8.740E-01  8.740E-01  1.451E+00   9.146E-01   4.501E-01
 30  2002   0.165   4.801E+00   5.167E+00   8.510E-01  8.510E-01  1.585E+00   7.776E-01   5.116E-01
 31  2003   0.194   5.535E+00   5.822E+00   1.130E+00  1.130E+00  1.701E+00   9.162E-01   5.899E-01
 32  2004   0.184   6.106E+00   6.412E+00   1.182E+00  1.182E+00  1.788E+00   8.703E-01   6.507E-01
 33  2005           6.712E+00                                                             7.153E-01
```

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RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED)   weighout cpue
----
Data type CC: CPUE-catch series   Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Resid in log yield
1	1973	*	2.390E+00	0.0370	3.940E-01	3.940E-01	0.00000	0.000E+00
2	1974	*	2.612E+00	0.0504	5.860E-01	5.860E-01	0.00000	0.000E+00
3	1975	*	2.871E+00	0.0555	7.100E-01	7.100E-01	0.00000	0.000E+00
4	1976	*	3.049E+00	0.0744	1.010E+00	1.010E+00	0.00000	0.000E+00
5	1977	*	3.052E+00	0.1532	2.082E+00	2.082E+00	0.00000	0.000E+00
6	1978	*	2.820E+00	0.2593	3.257E+00	3.257E+00	0.00000	0.000E+00
7	1979	2.789E+00	2.419E+00	0.3684	3.968E+00	3.968E+00	-0.14252	
8	1980	2.702E+00	1.977E+00	0.4417	3.889E+00	3.889E+00	-0.31247	
9	1981	2.612E+00	1.581E+00	0.4971	3.499E+00	3.499E+00	-0.50235	
10	1982	1.591E+00	1.381E+00	0.3236	1.990E+00	1.990E+00	-0.14170	
11	1983	1.041E+00	1.337E+00	0.3152	1.877E+00	1.877E+00	0.25023	
12	1984	1.000E+00	1.282E+00	0.3518	2.009E+00	2.009E+00	0.24870	
13	1985	8.920E-01	1.208E+00	0.3645	1.961E+00	1.961E+00	0.30335	
14	1986	1.085E+00	1.126E+00	0.3889	1.950E+00	1.950E+00	0.03713	
15	1987	1.269E+00	8.433E-01	0.8548	3.210E+00	3.210E+00	-0.40870	
16	1988	7.500E-01	6.016E-01	0.5080	1.361E+00	1.361E+00	-0.22042	
17	1989	6.500E-01	9.540E-01	0.1069	4.540E-01	4.540E-01	0.38373	
18	1990	6.660E-01	1.020E+00	0.1924	8.740E-01	8.740E-01	0.42649	
19	1991	6.330E-01	8.499E-01	0.3142	1.189E+00	1.189E+00	0.29460	
20	1992	8.110E-01	8.116E-01	0.4573	1.653E+00	1.653E+00	0.00080	
21	1993	7.610E-01	6.754E-01	0.6111	1.838E+00	1.838E+00	-0.11934	
22	1994	*	9.104E-01	0.1939	7.860E-01	7.860E-01	0.00000	0.000E+00
23	1995	*	7.560E-01	0.1978	6.660E-01	6.660E-01	0.00000	0.000E+00
24	1996	*	8.285E-01	0.3038	1.121E+00	1.121E+00	0.00000	0.000E+00
25	1997	*	7.707E-01	0.5274	1.810E+00	1.810E+00	0.00000	0.000E+00
26	1998	*	6.719E-01	0.4485	1.342E+00	1.342E+00	0.00000	0.000E+00
27	1999	*	7.059E-01	0.1670	5.250E-01	5.250E-01	0.00000	0.000E+00
28	2000	*	8.588E-01	0.1323	5.060E-01	5.060E-01	0.00000	0.000E+00
29	2001	*	1.013E+00	0.1937	8.740E-01	8.740E-01	0.00000	0.000E+00
30	2002	*	1.160E+00	0.1647	8.510E-01	8.510E-01	0.00000	0.000E+00
31	2003	*	1.307E+00	0.1941	1.130E+00	1.130E+00	0.00000	0.000E+00
32	2004	*	1.440E+00	0.1844	1.182E+00	1.182E+00	0.00000	0.000E+00

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1
                  -1        -0.75      -0.5      -0.25       0         0.25       0.5        0.75       1
                  |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual   ----------------------------------------------------------------------------------------
1973    0.0000                                                     |
1974    0.0000                                                     |
1975    0.0000                                                     |
1976    0.0000                                                     |
1977    0.0000                                                     |
1978    0.0000                                                     |
1979   -0.1425                                            ======|
1980   -0.3125                                    ============|
1981   -0.5023                           ====================|
1982   -0.1417                                            ======|
1983    0.2502                                                     |==========
1984    0.2487                                                     |==========
1985    0.3034                                                     |============
1986    0.0371                                                     |=
1987   -0.4087                                 ================|
1988   -0.2204                                        =========|
1989    0.3837                                                     |===============
1990    0.4265                                                     |=================
1991    0.2946                                                     |============
1992    0.0008                                                     |
1993   -0.1193                                            =====|
1994    0.0000                                                     |
1995    0.0000                                                     |
1996    0.0000                                                     |
1997    0.0000                                                     |
1998    0.0000                                                     |
1999    0.0000                                                     |
2000    0.0000                                                     |
2001    0.0000                                                     |
2002    0.0000                                                     |
2003    0.0000                                                     |
2004    0.0000                                                     |
                  ----------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED)   turner

Data type I1: Year-average biomass index   Series weight: 1.000

| | | Observed | Estimated | Estim | Observed | Model | Resid in | Resid in |
Obs	Year	effort	effort	F	index	index	log index	index
1	1973	1.000E+00	1.000E+00	0.0	2.060E-01	1.100E-01	0.62756	9.602E-02
2	1974	1.000E+00	1.000E+00	0.0	1.350E-01	1.202E-01	0.11598	1.478E-02
3	1975	1.000E+00	1.000E+00	0.0	9.600E-02	1.321E-01	-0.31930	-3.611E-02
4	1976	1.000E+00	1.000E+00	0.0	1.140E-01	1.403E-01	-0.20760	-2.630E-02
5	1977	1.000E+00	1.000E+00	0.0	1.250E-01	1.405E-01	-0.11666	-1.547E-02
6	1978	1.000E+00	1.000E+00	0.0	1.320E-01	1.298E-01	0.01694	2.217E-03
7	1979	1.000E+00	1.000E+00	0.0	1.000E-01	1.113E-01	-0.10706	-1.130E-02
8	1980	1.000E+00	1.000E+00	0.0	9.100E-02	9.098E-02	0.00027	2.474E-05
9	1981	1.000E+00	1.000E+00	0.0	9.000E-02	7.274E-02	0.21297	1.726E-02
10	1982	1.000E+00	1.000E+00	0.0	5.100E-02	6.354E-02	-0.21990	-1.254E-02
11	1983	0.000E+00	0.000E+00	0.0	*	6.153E-02	0.00000	0.0
12	1984	0.000E+00	0.000E+00	0.0	*	5.901E-02	0.00000	0.0
13	1985	0.000E+00	0.000E+00	0.0	*	5.560E-02	0.00000	0.0
14	1986	0.000E+00	0.000E+00	0.0	*	5.182E-02	0.00000	0.0
15	1987	0.000E+00	0.000E+00	0.0	*	3.881E-02	0.00000	0.0
16	1988	0.000E+00	0.000E+00	0.0	*	2.769E-02	0.00000	0.0
17	1989	0.000E+00	0.000E+00	0.0	*	4.390E-02	0.00000	0.0
18	1990	0.000E+00	0.000E+00	0.0	*	4.695E-02	0.00000	0.0
19	1991	0.000E+00	0.000E+00	0.0	*	3.911E-02	0.00000	0.0
20	1992	0.000E+00	0.000E+00	0.0	*	3.735E-02	0.00000	0.0
21	1993	0.000E+00	0.000E+00	0.0	*	3.108E-02	0.00000	0.0
22	1994	0.000E+00	0.000E+00	0.0	*	4.190E-02	0.00000	0.0
23	1995	0.000E+00	0.000E+00	0.0	*	3.479E-02	0.00000	0.0
24	1996	0.000E+00	0.000E+00	0.0	*	3.813E-02	0.00000	0.0
25	1997	0.000E+00	0.000E+00	0.0	*	3.547E-02	0.00000	0.0
26	1998	0.000E+00	0.000E+00	0.0	*	3.092E-02	0.00000	0.0
27	1999	0.000E+00	0.000E+00	0.0	*	3.249E-02	0.00000	0.0
28	2000	0.000E+00	0.000E+00	0.0	*	3.952E-02	0.00000	0.0
29	2001	0.000E+00	0.000E+00	0.0	*	4.662E-02	0.00000	0.0
30	2002	0.000E+00	0.000E+00	0.0	*	5.339E-02	0.00000	0.0
31	2003	0.000E+00	0.000E+00	0.0	*	6.017E-02	0.00000	0.0
32	2004	0.000E+00	0.000E+00	0.0	*	6.626E-02	0.00000	0.0

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -1        -0.75      -0.5       -0.25      0          0.25       0.5        0.75       1
                   |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -----------------------------------------------------------------------------------------
1973    0.6276                                             |========================
1974    0.1160                                             |=====
1975   -0.3193                                  =============|
1976   -0.2076                                     =======|
1977   -0.1167                                       =====|
1978    0.0169                                             |=
1979   -0.1071                                        ====|
1980    0.0003                                             |
1981    0.2130                                             |=========
1982   -0.2199                                    ========|
1983    0.0000                                             |
1984    0.0000                                             |
1985    0.0000                                             |
1986    0.0000                                             |
1987    0.0000                                             |
1988    0.0000                                             |
1989    0.0000                                             |
1990    0.0000                                             |
1991    0.0000                                             |
1992    0.0000                                             |
1993    0.0000                                             |
1994    0.0000                                             |
1995    0.0000                                             |
1996    0.0000                                             |
1997    0.0000                                             |
1998    0.0000                                             |
1999    0.0000                                             |
2000    0.0000                                             |
2001    0.0000                                             |
2002    0.0000                                             |
2003    0.0000                                             |
2004    0.0000                                             |
                   -----------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED)   vtr

Data type I1: Year-average biomass index   Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1973	0.000E+00	0.000E+00	0.0	*	4.173E+00	0.00000	0.0
2	1974	0.000E+00	0.000E+00	0.0	*	4.562E+00	0.00000	0.0
3	1975	0.000E+00	0.000E+00	0.0	*	5.013E+00	0.00000	0.0
4	1976	0.000E+00	0.000E+00	0.0	*	5.324E+00	0.00000	0.0
5	1977	0.000E+00	0.000E+00	0.0	*	5.330E+00	0.00000	0.0
6	1978	0.000E+00	0.000E+00	0.0	*	4.925E+00	0.00000	0.0
7	1979	0.000E+00	0.000E+00	0.0	*	4.223E+00	0.00000	0.0
8	1980	0.000E+00	0.000E+00	0.0	*	3.452E+00	0.00000	0.0
9	1981	0.000E+00	0.000E+00	0.0	*	2.760E+00	0.00000	0.0
10	1982	0.000E+00	0.000E+00	0.0	*	2.411E+00	0.00000	0.0
11	1983	0.000E+00	0.000E+00	0.0	*	2.335E+00	0.00000	0.0
12	1984	0.000E+00	0.000E+00	0.0	*	2.239E+00	0.00000	0.0
13	1985	0.000E+00	0.000E+00	0.0	*	2.110E+00	0.00000	0.0
14	1986	0.000E+00	0.000E+00	0.0	*	1.966E+00	0.00000	0.0
15	1987	0.000E+00	0.000E+00	0.0	*	1.473E+00	0.00000	0.0
16	1988	0.000E+00	0.000E+00	0.0	*	1.051E+00	0.00000	0.0
17	1989	0.000E+00	0.000E+00	0.0	*	1.666E+00	0.00000	0.0
18	1990	0.000E+00	0.000E+00	0.0	*	1.782E+00	0.00000	0.0
19	1991	0.000E+00	0.000E+00	0.0	*	1.484E+00	0.00000	0.0
20	1992	0.000E+00	0.000E+00	0.0	*	1.417E+00	0.00000	0.0
21	1993	0.000E+00	0.000E+00	0.0	*	1.179E+00	0.00000	0.0
22	1994	0.000E+00	0.000E+00	0.0	*	1.590E+00	0.00000	0.0
23	1995	1.000E+00	1.000E+00	0.0	1.005E+00	1.320E+00	-0.27275	-3.151E-01
24	1996	1.000E+00	1.000E+00	0.0	1.398E+00	1.447E+00	-0.03433	-4.883E-02
25	1997	1.000E+00	1.000E+00	0.0	2.350E+00	1.346E+00	0.55746	1.004E+00
26	1998	1.000E+00	1.000E+00	0.0	1.388E+00	1.173E+00	0.16805	2.147E-01
27	1999	1.000E+00	1.000E+00	0.0	9.910E-01	1.233E+00	-0.21823	-2.417E-01
28	2000	1.000E+00	1.000E+00	0.0	1.000E+00	1.500E+00	-0.40524	-4.997E-01
29	2001	1.000E+00	1.000E+00	0.0	1.410E+00	1.769E+00	-0.22676	-3.589E-01
30	2002	1.000E+00	1.000E+00	0.0	1.723E+00	2.026E+00	-0.16195	-3.029E-01
31	2003	1.000E+00	1.000E+00	0.0	2.779E+00	2.283E+00	0.19659	4.960E-01
32	2004	1.000E+00	1.000E+00	0.0	3.741E+00	2.514E+00	0.39744	1.227E+00

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3
                 -1        -0.75      -0.5       -0.25       0         0.25       0.5        0.75       1
                 |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual  --------------------------------------------------------------------------------
1973    0.0000                                                    |
1974    0.0000                                                    |
1975    0.0000                                                    |
1976    0.0000                                                    |
1977    0.0000                                                    |
1978    0.0000                                                    |
1979    0.0000                                                    |
1980    0.0000                                                    |
1981    0.0000                                                    |
1982    0.0000                                                    |
1983    0.0000                                                    |
1984    0.0000                                                    |
1985    0.0000                                                    |
1986    0.0000                                                    |
1987    0.0000                                                    |
1988    0.0000                                                    |
1989    0.0000                                                    |
1990    0.0000                                                    |
1991    0.0000                                                    |
1992    0.0000                                                    |
1993    0.0000                                                    |
1994    0.0000                                                    |
1995   -0.2728                                        ==========|
1996   -0.0343                                                 =|
1997    0.5575                                                  |=====================
1998    0.1681                                                  |=======
1999   -0.2182                                          ========|
2000   -0.4052                                  ===============|
2001   -0.2268                                         ========|
2002   -0.1619                                            ======|
2003    0.1966                                                  |========
2004    0.3974                                                  |===============
                 --------------------------------------------------------------------------------
```

RESULTS OF BOOTSTRAPPED ANALYSIS

Param name	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
B1/Bmsy	1.000E+00	-7.798E-10	0.00%	1.000E+00	1.000E+00	1.000E+00	1.000E+00	4.293E-10	0.000
K	1.877E+01	-1.096E+00	-5.84%	1.632E+01	2.649E+01	1.803E+01	2.302E+01	4.990E+00	0.266
r	4.237E-01	1.179E+00	278.33%	2.675E-01	5.115E-01	3.272E-01	4.478E-01	1.206E-01	0.285
q(1)	2.245E-01	2.937E-02	13.08%	1.476E-01	2.702E-01	1.795E-01	2.426E-01	6.313E-02	0.281
q(2)	1.033E-02	2.189E-03	21.19%	7.588E-03	1.186E-02	8.500E-03	1.088E-02	2.380E-03	0.230
q(3)	3.921E-01	5.745E-02	14.65%	1.980E-01	5.707E-01	2.622E-01	4.644E-01	2.022E-01	0.516
MSY	1.988E+00	6.862E-01	34.52%	1.793E+00	2.092E+00	1.869E+00	2.024E+00	1.552E-01	0.078
Ye(2005)	1.827E+00	-8.667E-02	-4.74%	1.395E+00	2.085E+00	1.641E+00	1.996E+00	3.552E-01	0.194
Bmsy	9.384E+00	-5.482E-01	-5.84%	8.160E+00	1.325E+01	9.015E+00	1.151E+01	2.495E+00	0.266
Fmsy	2.118E-01	5.896E-01	278.33%	1.337E-01	2.557E-01	1.636E-01	2.239E-01	6.030E-02	0.285
fmsy(1)	9.434E-01	1.083E+00	114.80%	8.198E-01	1.031E+00	8.627E-01	9.743E-01	1.117E-01	0.118
fmsy(2)	2.050E+01	1.210E+01	59.05%	1.702E+01	2.361E+01	1.840E+01	2.188E+01	3.485E+00	0.170
fmsy(3)	5.403E-01	8.430E-01	156.04%	4.071E-01	8.735E-01	4.658E-01	6.768E-01	2.111E-01	0.391
F(0.1)	1.906E-01	5.306E-01	250.50%	1.204E-01	2.302E-01	1.472E-01	2.015E-01	5.427E-02	0.285
Y(0.1)	1.968E+00	6.793E-01	34.17%	1.775E+00	2.071E+00	1.850E+00	2.004E+00	1.536E-01	0.078
B/Bmsy	7.153E-01	8.117E-02	11.35%	4.507E-01	1.171E+00	5.497E-01	9.135E-01	3.638E-01	0.509
F/Fmsy	8.703E-01	1.169E-02	1.34%	5.173E-01	1.352E+00	6.803E-01	1.129E+00	4.489E-01	0.516
Y-ratio	9.189E-01	-7.335E-02	-7.98%	7.242E-01	9.989E-01	8.406E-01	9.887E-01	1.481E-01	0.161
f0.1(1)	8.491E-01	9.747E-01	103.32%	7.378E-01	9.277E-01	7.764E-01	8.769E-01	1.005E-01	0.118
f0.1(2)	1.845E+01	1.089E+01	53.14%	1.532E+01	2.125E+01	1.656E+01	1.969E+01	3.136E+00	0.170
f0.1(3)	4.862E-01	7.587E-01	140.44%	3.664E-01	7.861E-01	4.192E-01	6.091E-01	1.900E-01	0.391
q2/q1	4.602E-02	1.685E-03	3.66%	3.792E-02	5.511E-02	4.172E-02	5.007E-02	8.349E-03	0.181
q3/q1	1.746E+00	4.235E-02	2.43%	1.134E+00	2.350E+00	1.431E+00	2.042E+00	6.116E-01	0.350

NOTES ON BOOTSTRAPPED ESTIMATES

- The bootstrapped results shown were computed from 1000 trials.
- These results are conditional on the constraints placed upon MSY and r in the input file (ASPIC.INP).
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- Estimates of bias and relative bias are known to be highly imprecise and may not be informative.

Trials replaced for lack of convergence: 2
Trials replaced for MSY out-of-bounds: 6
Trials replaced for r out-of-bounds: 3
Residual-adjustment factor: 1.0801

APPENDIX C5: AIM Model results

(Combined NEFSC Weighout, VTR and Turner CPUE)

```
                              AIM Summary Report

Input File: C:\NIT\TILE\SARC41\AIM\TILECOMB3.DAT

Report Date: 27-Apr-05
Report Time: 15:44

First Year:      1973
Last Year:       2004
Number of Years: 32

Number of Indices: 1

Number of Years for Smoothing Abundance Indices: 4
Number of Years for Smoothing Relative F:        1
Number of Realizations for Randomization Test:   2000
Number of Bootstrap Iterations:                  2000
Random Number Generation Seed:                   123456
Number of Lags for Auto & Cross-correlation:     15

Relative F Smoothing Method is Lagged


          Catch          cpue


1973    3.9400E+02     5.9800E+00
1974    5.8600E+02     3.9200E+00
1975    7.1000E+02     2.7900E+00
1976    1.0100E+03     3.3100E+00
1977    2.0820E+03     3.6300E+00
1978    3.2570E+03     3.8300E+00
1979    3.9680E+03     2.9000E+00
1980    3.8890E+03     2.6400E+00
1981    3.4990E+03     2.6100E+00
1982    1.9900E+03     1.4800E+00
1983    1.8760E+03     1.0450E+00
1984    2.0090E+03     1.0000E+00
1985    1.9610E+03     8.9200E-01
1986    1.9500E+03     1.0930E+00
1987    3.2100E+03     1.2860E+00
1988    1.3610E+03     7.6600E-01
1989    4.5400E+02     6.5600E-01
1990    8.7400E+02     6.6900E-01
1991    1.1890E+03     6.4000E-01
1992    1.6530E+03     8.2300E-01
1993    1.8380E+03     7.5600E-01
1994    7.8600E+02     4.5700E-01
1995    6.6600E+02     5.3600E-01
1996    1.1210E+03     7.3400E-01
1997    1.8100E+03     1.2520E+00
1998    1.3420E+03     7.4100E-01
1999    5.2500E+02     5.2400E-01
2000    5.0600E+02     5.2400E-01
2001    8.7400E+02     7.5100E-01
2002    8.5100E+02     9.1600E-01
2003    1.1300E+03     1.4860E+00
2004    1.1820E+03     2.1290E+00

Base Case Results
                    cpue

     Replacement    Relative
        Ratio          F
```

```
1973    N/A          65.8862876
1974    N/A          149.4897959
1975    N/A          254.4802867
1976    N/A          305.1359517
1977    0.9075000    573.5537190
1978    1.1223443    850.3916449
1979    0.8554572    1368.2758621
1980    0.7724945    1473.1060606
1981    0.8030769    1340.6130268
1982    0.4941569    1344.5945946
1983    0.4340602    1795.2153110
1984    0.5144695    2009.0000000
1985    0.5815811    2198.4304933
1986    0.9898121    1784.0805124
1987    1.2764268    2496.1119751
1988    0.7173964    1776.7624021
1989    0.6499876    692.0731707
1990    0.7040253    1306.4275037
1991    0.7580693    1857.8125000
1992    1.2054193    2008.5054678
1993    1.0846485    2431.2169312
1994    0.6329640    1719.9124726
1995    0.8011958    1242.5373134
1996    1.1415241    1527.2479564
1997    2.0169150    1445.6869010
1998    0.9949648    1811.0661269
1999    0.6423537    1001.9083969
2000    0.6447247    965.6488550
2001    0.9878329    1163.7816245
2002    1.4425197    929.0393013
2003    2.1893186    760.4306864
2004    2.3160185    555.1902302
```

Simple Regression Results

LN(Replacement Ratio) = A + B * LN(Relative F)

cpue

```
Coefficient                          A              B

Estimated Value               2.1716E+00    -3.1657E-01
Std Error Coeff               1.3898E+00     1.9275E-01
t Statistic                   1.5626E+00    -1.6424E+00
p-Value (2 Sided)             1.3025E-01     1.1255E-01
Variance Inflation Factor     3.1191E+02     1.0000E+00
```

Relative F (for ln(Replacement Ratio = 0) = 9.530539E+02

Analysis of Variance

```
Degrees of Freedom for Regression                  1.0000E+00
Degrees of Freedom for Error                       2.6000E+01
Total Degrees of Freedom                           2.7000E+01
Sum of Squares for Regression                      4.6770E-01
Sum of Squares for Error                           4.5080E+00
Total Sum of Squares                               4.9757E+00
Regression Mean Square                             4.6770E-01
Error Mean Square                                  1.7338E-01
F-Statistic                                        2.6975E+00
p-Value                                            1.1255E-01
R Squared (percent)                                9.3998E+00
Adjusted R Squared (percent)                       5.9152E+00
Estimated Standard deviation of model error        4.1639E-01
Mean of response (dependent) variable             -1.0730E-01
Coefficient of Variation (percent)                -3.8808E+02
```

Least Absolute Value Regression Results

41st SAW Assessment Report   235

```
1973    N/A          65.8862876
1974    N/A          149.4897959
1975    N/A          254.4802867
1976    N/A          305.1359517
1977    0.9075000    573.5537190
1978    1.1223443    850.3916449
1979    0.8554572    1368.2758621
1980    0.7724945    1473.1060606
1981    0.8030769    1340.6130268
1982    0.4941569    1344.5945946
1983    0.4340602    1795.2153110
1984    0.5144695    2009.0000000
1985    0.5815811    2198.4304933
1986    0.9898121    1784.0805124
1987    1.2764268    2496.1119751
1988    0.7173964    1776.7624021
1989    0.6499876    692.0731707
1990    0.7040253    1306.4275037
1991    0.7580693    1857.8125000
1992    1.2054193    2008.5054678
1993    1.0846485    2431.2169312
1994    0.6329640    1719.9124726
1995    0.8011958    1242.5373134
1996    1.1415241    1527.2479564
1997    2.0169150    1445.6869010
1998    0.9949648    1811.0661269
1999    0.6423537    1001.9083969
2000    0.6447247    965.6488550
2001    0.9878329    1163.7816245
2002    1.4425197    929.0393013
2003    2.1893186    760.4306864
2004    2.3160185    555.1902302
```

Simple Regression Results

LN(Replacement Ratio) = A + B * LN(Relative F)

cpue

```
Coefficient                          A              B

Estimated Value               2.1716E+00    -3.1657E-01
Std Error Coeff               1.3898E+00     1.9275E-01
t Statistic                   1.5626E+00    -1.6424E+00
p-Value (2 Sided)             1.3025E-01     1.1255E-01
Variance Inflation Factor     3.1191E+02     1.0000E+00
```

Relative F (for ln(Replacement Ratio = 0) = 9.530539E+02

Analysis of Variance

```
Degrees of Freedom for Regression                  1.0000E+00
Degrees of Freedom for Error                       2.6000E+01
Total Degrees of Freedom                           2.7000E+01
Sum of Squares for Regression                      4.6770E-01
Sum of Squares for Error                           4.5080E+00
Total Sum of Squares                               4.9757E+00
Regression Mean Square                             4.6770E-01
Error Mean Square                                  1.7338E-01
F-Statistic                                        2.6975E+00
p-Value                                            1.1255E-01
R Squared (percent)                                9.3998E+00
Adjusted R Squared (percent)                       5.9152E+00
Estimated Standard deviation of model error        4.1639E-01
Mean of response (dependent) variable             -1.0730E-01
Coefficient of Variation (percent)                -3.8808E+02
```

Least Absolute Value Regression Results

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```
LN(Replacement Ratio) = A + B * LN(Relative F)
cpue

Coefficient                             A              B
Estimated Value                     8.1748E-01    -1.4398E-01
Sum of Absolute Value of Error    = 9.1166E+00

Relative F (for ln(Replacement Ratio = 0) = 2.922861E+02
```

APPENDIX C6: Length-based YPR

```
##      Length Based Yield Per Recruit Model
##      Version 1.2
##      Date & Time of Run: 22 Apr 2005   16:57
##      Input File Name: c:\nit\tile\sarc41\ypr\tlenypr-log2.dat

 Model Title: tilefish

 Fishing Mortality Upper Bound            =      2.0000
 Fishing Mortality Calculation Increment  =      0.0001
 Fishing Mortality Printing Increment     =        0.01

 Natural Mortality                        =      0.1000

 Starting Length                          =      1.0000
 Ending Age of Projection (Years)         =     35.0000
 Age Step Increment                       =      0.1000

 Length Units                            = Centimeters
 Weight Units                            = Kilograms

 Von Bertalanffy Growth Equation Parameters
 L-Infinity                               =     97.6000
 K                                        =      0.1620

 Length-Weight Equation Parameters
 Ln(A)                                    =    -12.3114
 B                                        =      3.2835

 Fishery Mortality Selectivity
 Single Logistic Equation Parameters
 Alpha                                    =    -18.9569
 Beta                                     =      0.4693
 L-50 (Calculated)                        =     40.3896

 Matural Mortality Selectivity
 Natural Mortality is Constant with Value =      0.1000

 Maturity Ogive Equation Parameters
 Alpha                                    =    -11.6211
 Beta                                     =      0.2374
 L-50 (Calculated)                        =     48.9618


 Reference Point       F          YPR        SSBR         TSBR
 F Zero            0.00000     0.00000     51.53361     53.26153
 F-01             0.08470     1.78983     20.34513     21.96114
 F-Max            0.13870     1.90241     12.95707     14.51105
 F at   40 %MSP   0.08320     1.78180     20.62892     22.24674
```